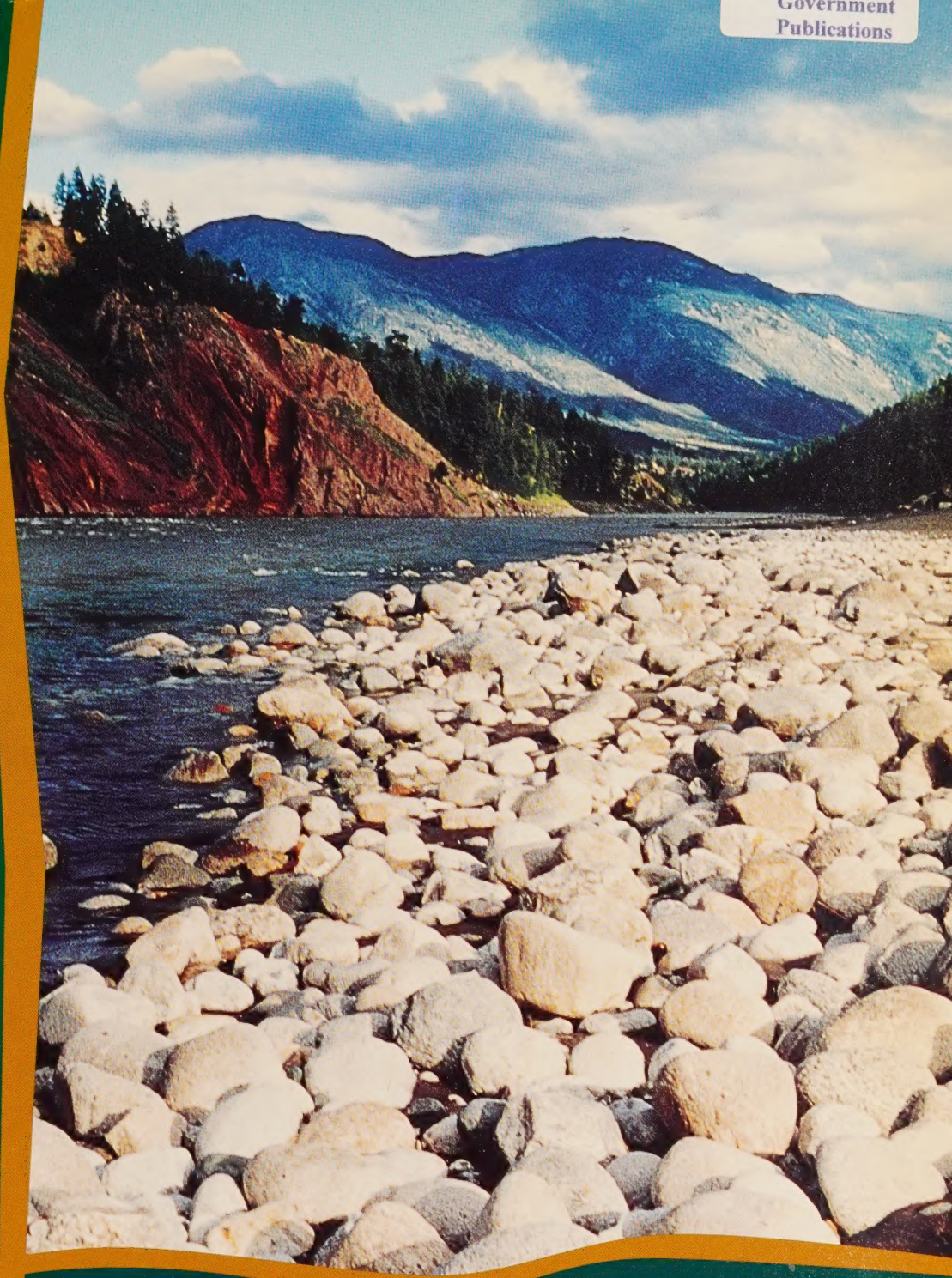
Rapport final
Final Report

FRASER RIVER ACTION PLAN
PLAN D'ACTION DU FRASER

Canada

Introductio



FRASER RIVER ACTION PLAN

Canada

ECOSYSTEM INITIATIVES

Across Canada, individuals, communities, and governments are taking up the challenge of sustainable development. We are working together to ensure that our children benefit from a healthy environment and the full richness of Canada's natural legacy.

Ecosystem initiatives respond to the unique problems of targeted areas and communities and address environmental, economic, and social concerns. They are characterized by a number of principles, including:

- an ecosystem approach — recognizing the interrelationships between land, air, water, wildlife, and human activities;
- decisions based on sound science — including natural and social sciences combined with local and traditional knowledge;
- federal–provincial–territorial partnerships — governments working together to achieve the highest level of environmental quality for all Canadians;
- a citizen/community base — working with individuals, communities, Aboriginal peoples, industry, and governments in the design and implementation of initiatives;
- pollution prevention — promoting a precautionary approach.

Ecosystem initiatives help Canadians achieve environmental results through partnerships, pooling resources, focusing science, coordinating efforts, sharing information and experiences, and generating a broad basis of support. Moreover, they help build the capacity of all the players involved to make better decisions and to effect change.

Environment Canada works with a broad spectrum of partners to achieve environmental results and sustainable development. Through ecosystem initiatives, Environment Canada is able to address priority areas and issues of concern — ensuring that Canadians have clean air and water, protecting and conserving nature, and taking action on climate change.

Environment Canada is engaged in a number of initiatives where we promote an ecosystem approach. Large ecosystem initiatives include

- the Atlantic Coastal Action Program
- the St. Lawrence Action Plan Vision 2000
- Great Lakes 2000
- the Northern River Basins Study/Northern Rivers Ecosystem Initiative
- the Fraser River Action Plan/Georgia Basin Ecosystem Initiative.

Environment Canada recently completed the Fraser River Action Plan, a seven-year initiative in British Columbia, and has also begun consultations on the Northern Ecosystem Initiative.

http://www.ec.gc.ca/ecosyst/infodoc.html

Additional copies of this report can be downloaded from the FRAP web site (http://www.pyr.ec.gc.ca/ec/frap/index.html) or by writing to:

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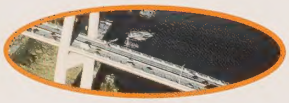


FRASER RIVER BASIN

Introduction and Highlights

AN ACTION PLAN FOR THE FRASER RIVER

Centred on the most important waterway on Canada's west coast, the Fraser watershed contains two-thirds of British Columbia's population, three-quarters of its value-added manufacturing, and a large proportion of its commercial, recreational, and aboriginal food fisheries.

During the 1980s, rapidly growing industrial activity and urbanization in the Fraser Basin were raising environmental concerns. Pollution from urban areas, agriculture, and forestry was contaminating watercourses and groundwater. The federal Minister of the Environment stated the fears of many observers that contamination had reached the stage that the overall health of the Fraser River might be in jeopardy. Vital fish and wildlife habitat was being lost to urbanization, industrialization, agriculture, logging, dams, water diversions, and other land uses. Nevertheless, though conditions were critical, environmental authorities felt that the watershed could respond and recover if the proper steps were taken.

EC AQUATICS SECTION

The Alex Fraser Bridge spans the main channel near Vancouver.

RICK McKELVEY

A tranquil morning by a marsh

In 1990, the Fraser Basin was singled out in the federal budget as a major freshwater system requiring priority action. In 1991, as part of the Green Plan, the government established a sustainability program called the Fraser River Action Plan (FRAP). Jointly sponsored by the Departments of Environment and Fisheries and Oceans, FRAP was modelled on the successful Fraser River Estuary Management Program and other national initiatives such as the St Lawrence and Great Lakes Action Plans, but went beyond those programs by focusing on the whole watershed and its governance.

For seven years, FRAP was a leader, partner, and cosponsor of an array of research and action initiatives on critical aspects of the health of the Fraser watershed. With FRAP's support and partnership, British Columbians learned a great deal about their largest river system and its interactions with their lives and took some important steps forward in its management. Now that FRAP has ended, this final public report provides an opportunity to review its accomplishments, assess our new understanding of the Fraser ecosystem, and draw some lessons for the future. The most important of these may be that ecosystem management must continue as population growth and economic development intensify the pressures on the Fraser Basin and its inhabitants — of all species. Building on FRAP's work, now more than ever, public involvement is essential to maintain the sustainability of the Fraser Basin.

AN ECOSYSTEM APPROACH

FRAP was designed to rise above the barriers created by differences between jurisdictions, mandates, and policies. The initiative was intended to foster a cooperative, multi-organizational approach to restoring the environmental health of an entire watershed. To accomplish this purpose, FRAP's strategy had four parts:

FRAP was intended to foster a cooperative approach to restoring the environmental health of the watershed

- Focus on ecosystems: shift the focus from individual sites, chemicals and species to ecosystem interactions. What matters more than particular contaminants or practices is the way all influences combine and interact as a system. Any action taken on a part of the system is likely to affect, or be affected by, other parts as well. This concern for interactions introduced a scientific dimension to FRAP from the beginning: to understand ecosystem interactions requires scientific research and interpretation.

- Address the whole watershed: take the watershed as an appropriate unit for ecosystem analysis — each tributary watershed and all of them together constituting a full watershed from the ocean up to all headwaters. This orientation to a natural unit (in contrast, say, to community boundaries) was consistent with the emphasis on wildlife and fish in the mandates of FRAP's two founding federal departments: Environment and Fisheries and Oceans. Study boundaries would be set by the natural landscapes that tie together to form the Fraser River Basin.

- Work cooperatively: encourage partnerships, joint action, and collective stewardship for effective watershed management. A watershed approach requires management that rises

EC AQUATICS SECTION

Alpine headwaters

above competing jurisdictions. FRAP itself originated in a partnership between federal departments, and a continuing strategy has been to develop and support projects in partnership with other governments and organizations. A cooperative emphasis recognizes that problems should be considered from, and proposed solutions should be designed to accommodate, a variety of perspectives and interests.

• Involve the public: help British Columbians understand how their actions can harm or enhance their landscape and quality of life. Because of the improvements made in the 1990s in industrial and municipal discharges, the pressures on the Basin will increasingly come from the expansion of urban areas. People's choices and behaviour will be involved in sustaining the future health of the Basin. To promote environmentally sensitive choices, FRAP conducted research on public environmental perceptions, developed guidelines for small industries, sponsored workshops, helped support educational outreach such as the province's Green Team for school presentations, and published and distributed hundreds of reports, fact sheets, and brochures.

FRAP helps British Columbians understand how their actions can harm or enhance their landscape

These themes of ecosystem science, a watershed scope, partnership, and public education and action have characterized FRAP's activities over its seven-year life.

EC AQUATICS SECTION

Children and their parents learn about runoff.

EC AQUATICS SECTION

A NEW MODEL OF GOVERNANCE

Part of the reason for the concern over the Fraser watershed was a question of "governance": no organization was responsible for it as a whole system. Almost any department of every level of government might be responsible for selected aspects of it, according to their jurisdictions and mandates. But the interactions between the different aspects meant that any particular issue, such as pollution, would involve many branches of government, none of which could regard itself as responsible for solving the whole problem. As often happens in such cases, community members wishing to deal with a problem would find there was no entity to take leadership in mobilizing and coordinating the various jurisdictions and departments whose participation was needed for a solution.

EC AQUATICS SECTION

One of FRAP's goals, therefore, was to sponsor the creation of a body that would take responsibility for the well-being of the Fraser Basin as a whole. This would not be an easy matter. Jurisdictions and mandates, however subdivided and distributed, are legislated and cannot be ignored. Moreover, if a federal department (two in FRAP's case) attempted

One of FRAP's goals was to sponsor the creation of a body that would take responsibility for the well-being of the Fraser Basin

to establish such an organization, it would be seen by many as merely another branch or creature of the department. That would intensify rather than alleviate the divisions of responsibility. Somehow FRAP would have to be more a facilitator than a leader.

FRAP's approach was to build on the experience with government partnerships and community initiatives achieved by sister action plans across the nation. FRAP would be not a supervising creator but a sponsor, a supportive partner,

yet, in the end, just another stakeholder. FRAP promoted the development of a Management Board that (1) would be fully representative of stakeholders and interests, (2) would make decisions by consensus among Board members, and (3) would take the desired Basin-wide responsibility .

FRASER BASIN COUNCIL

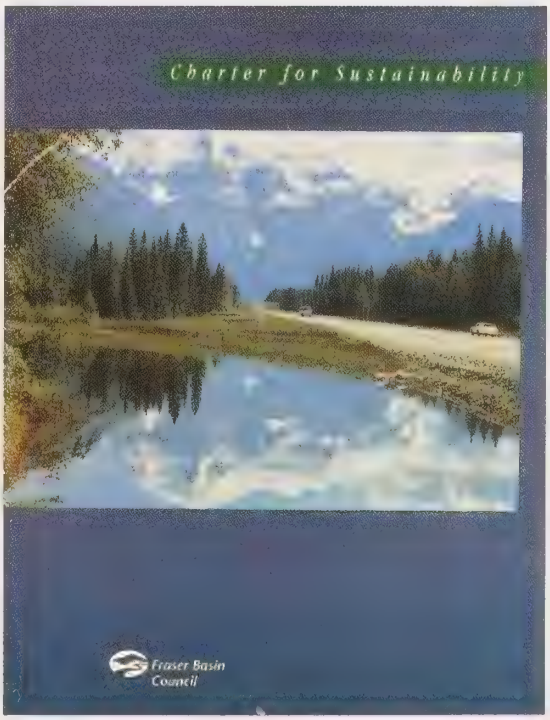
Members of the Fraser Basin Management Board

Accordingly, in 1992, with FRAP's sponsorship, the Fraser Basin Management Program was established with a 19-member Board and a staff. During its five-year lifetime, the Board was vigorously led by its chairs. It was as members of this Board that, often for the first time, forest workers, environmentalists, social activists, business representatives, and government officials met to learn of one another's concerns, find common ground, and work out environmental management strategies that all could support. The Board issued a State of the Basin report in 1995, covering topics from population growth to water resources management to building new relationships with First Nations communities, and followed that with two report cards on sustainability issues in the Basin.

The Board's workshops also provided a forum where, over five years, thousands of people expressed their visions of community, learned first-hand about environmental issues in the Fraser Basin, and participated in activities aimed at achieving sustainability.

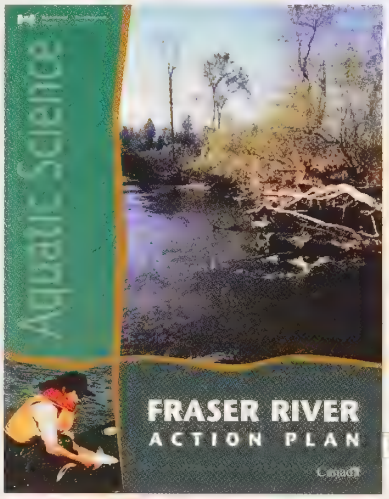
A similar model of governance was adopted at the local level. Four regional coordinators living in Basin communities played a strong role in advising land use planning processes, developing community stewardship programs, facilitating stakeholder committees, and helping resolve longstanding conflicts.

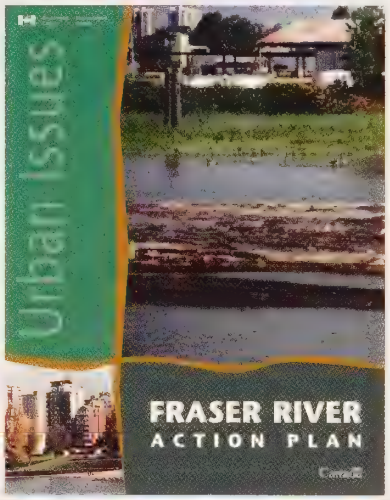
As its mandate drew to a conclusion, it was recognized that the governance model the Board had achieved was indispensable for the sustainability of the Fraser Basin. In its Charter for Sustainability, the Board called for a new Fraser Basin Council to continue the progress that had begun.

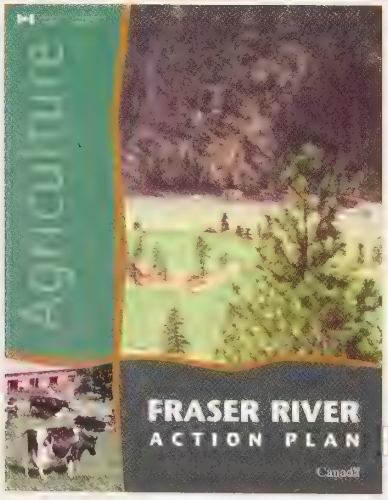


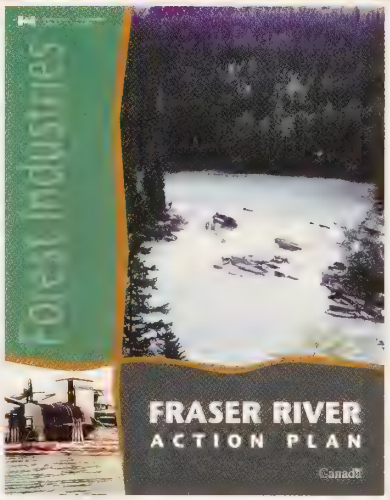
CHALLENGES AND ACCOMPLISHMENTS

The research projects and initiatives fostered and supported by FRAP are described in detail in four accompanying technical documents, available from Environment Canada's Vancouver offices. For ease of understanding here, projects and initiatives have been divided into four categories which reflect the main areas of concern: aquatic science, urban issues, agriculture, and forest industries. This introduction looks briefly at each, and more detail is given in a module devoted to each area.









GETTING THE MESSAGE OUT

Involving the public and raising awareness have been part of FRAP's strategy from the beginning. A continuing communications effort has accompanied research and action initiatives. The 200-odd reports of studies by scientists and consultants have been published and distributed and will be available soon on CD-ROM. The numerous programs cosponsored by FRAP have generated books, fact sheets, brochures, videos, and other media on a vast range of topics related to the Fraser Basin. The FRAP web site (www.pyr.ec.gc.ca/ec/frap/index.html) has helped thousands of inquirers to find out more about the Fraser Basin, the threats to it, and the actions being taken. Two communications initiatives have reached out to elementary and high school students: with the Province, FRAP cosponsored an Eco Education Program for Grades 4 to 7 entitled the Green Team, with resources, activities, and two groups of actor/presenters who use story workshops to communicate concepts and attitudes; FRAP also sponsored a well-known website on ecology and wildlife for youth (www.sturgeongeneral.org).

In 1997, the Department of Fisheries and Oceans published a report on its own contributions to FRAP: Legacy for the Fraser: A Final Report on the Fraser River Action Plan by Fisheries and Oceans Canada, 1991–1997.

The modules of this report by Environment Canada are part of a final communications initiative to encourage the continuation of FRAP's legacy. Readers wishing further scientific and technical information on topics outlined here may follow them up in technical synthesis reports, which introduce and summarize the findings of the large repertoire of scientific and investigative studies sponsored by FRAP during its seven years of activity. These technical reports are:

Health of the Fraser River Aquatic Ecosystem: A Synthesis of Research Conducted under the Fraser River Action Plan, edited by Colin Gray and Taina Tuominen (DOE FRAP 1998-11)

Fraser River Action Plan, Pollution Abatement Technical Summary Report (DOE-FRAP 1998-01)

Fraser River Action Plan, Burrard Inlet Technical Summary Report (DOE-FRAP 1998-02)

FRAP Habitat Conservation and Restoration Program, Review of Results

Environment Canada Pacific & Yukon Green Lane www.pyr.ec.gc.ca

AQUATIC SCIENCE

The scientific context

FRAP set out to make significant improvements in the Fraser Basin's environmental health. For scientists, this sensible policy goal turned out to be extraordinarily ambitious. They were of course accustomed to the difficulties of measuring a multitude of variables. The key challenge was a deeper

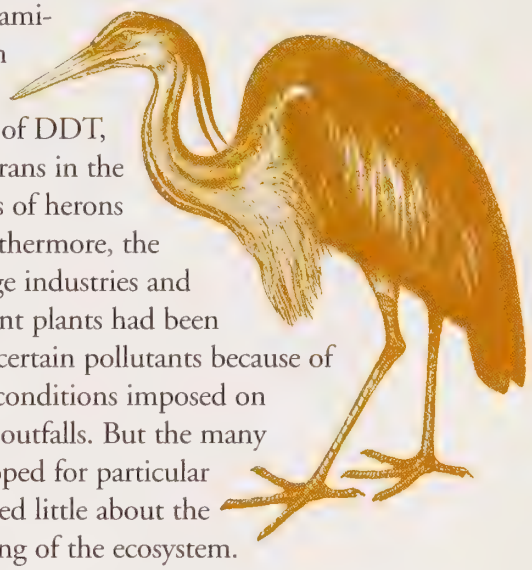
EC AQUATICS SECTION

Collecting organism samples from the river bottom

one: measuring an improvement means comparing an "after" to a "before." FRAP scientists soon found that in the Fraser Basin, for all the scattered signs of environmental stress which had led to FRAP's creation, reliable series of historical contaminant measurements were few. There was no "before" baseline assessment of ecosystem health against which FRAP-fostered improvements could be demonstrated.

There were several quite straightforward reasons for this lack of baseline data:

- The data sets that existed reflected previous research priorities and administrative requirements. For example, scientists, long alert to the harm to birds caused by certain contaminants, had been tracking concentrations of DDT, dioxins, and furans in the tissues and eggs of herons and eagles. Furthermore, the effluents of large industries and sewage treatment plants had been monitored for certain pollutants because of the regulatory conditions imposed on their discharge outfalls. But the many data sets developed for particular purposes revealed little about the overall well-being of the ecosystem.



- The conditions indicated by those data sets were already changing quickly — because of the changes triggered by the data findings themselves. In the late 1980s and early 1990s, as pulp and paper mills and lumber companies upgraded their processes to meet tightening regulations, their outputs of some contaminants dropped dramatically, with results that gave scientists better insight into ecosystem health.

FRAP set out to make significant improvements in the Fraser Basin's environmental health

DAVID DE ROSA

Bald Eagle

• The growth of scientific understanding of contaminants, combined with the continual process changes in industry, meant that new contaminants of concern kept being discovered. These were substances for which no monitoring record existed.

• The challenge was not simply to identify contaminants but to decide which ones were especially important and how best to measure them. This involved understanding where the contaminants originated, the pathways by which they circulated, came in contact with, were passed between, and accumulated in, plants and animals, and what concentrations were harmful to which, at which life stage.

The task facing FRAP scientists was therefore not so much to measure improvements as to work out the ecosystem implications of such measurements as were available and to come up with new kinds of measurements that would be particularly meaningful in the Fraser Basin.

Making a difference

Scientists from the federal government and universities worked with field personnel to understand ecosystem connections and identify strategies for mitigation of impacts. Enforcement staff, who conduct inspections of regulated activities and technologies, and abatement staff, who work with firms to help them make improvements and meet regulations, provided valuable insights into contaminant origins and pathways. For example, FRAP studies show that:

• There have been dramatic reductions in dioxins and furans in effluent being discharged from pulp mills and in residues of fungicides and heavy duty wood preservatives released by lumber companies. But emerging concerns about one substitute fungicide suggest an ongoing need for research into new chemicals.

• There have been decreases in the last twenty years in fish tissue concentrations of certain contaminants on which action was taken, such as PCBs, lead, arsenic, and mercury. Yet continuing symptoms of likely contaminant exposure in fish, such as certain enzyme reactions and odd pigmentation in livers call out for further investigation.

• Clams, plankton, and fish have mostly recolonized Sturgeon Bank following diversion of the Iona Island sewage treatment effluent to deeper water.

GERRY M'TCHELL

Sampling for contaminants

• Urban runoff from distributed ("non-point") sources is of increasing importance in polluting smaller rivers and the main river below New Westminster. The Brunette watershed in Burnaby, for example, still has considerable green space and riparian habitat, yet the water quality is frequently unsuitable for fish or recreational contact.

• Snowpacks and glaciers in the Rockies and Coast Ranges are accumulating contaminants transported in the air from distant continents. These contaminants are already being found in lakes near the glacier sources. Climate warming could accelerate the release of the accumulated contaminants from the snow and ice.

• Residues of long-banned substances such as DDT and toxaphene continue to show up in the Basin's fish. Much of this may be coming by air from foreign sources, though in the case of DDT, there has clearly been some illegal or accidental use.

Snowpacks and glaciers accumulate contaminants transported in the air from distant continents

• Pesticides still in use continue to pollute the ground and surface waters of the Lower Fraser Valley and enter the food chain to reach fish and birds.

• An overload of manure and fertilizers in the Lower Fraser Valley is polluting ground and surface waters with nutrients, particularly nitrate.

• The "white haze" experienced in the eastern parts of the Lower Fraser Valley, a rural version of urban smog, involves airborne particles formed partly from ammonia evaporating from livestock and poultry manure.

• Bed sediments and suspended sediments are good indicators of environmental quality.

Long range transport of airborne pollutants

• With innovative methods, bottom-dwelling organisms can be used as pollution indicators.

• Water control dikes and channels in the Fraser estuary have cut off the deposition of sediment that naturally maintained habitat and coastlines near the Fraser.

FRAP has publicized these findings in a variety of ways and Environment Canada will ensure that they are addressed in the environmental management initiatives and programs it has sponsored and launched.

FRAP scientists and other researchers considered the main causes of ecosystem stress in the Fraser Basin. They concluded that the greatest overall stresses originated in the urban, agricultural, and forest industry sectors. Two other sectors were determined to generate stress in more limited ways: the mining industry, based mainly in the dry interior, poses a significant runoff problem at specific sites; hydroelectric development and its effects on fish passage and habitat were addressed as part of the Department of Fisheries and Ocean's contribution to FRAP. Accordingly, scientific energies were focused on the first three sectors.

URBAN ISSUES

FRAP identified and addressed urban environmental issues on two broad fronts: pollution and elimination of natural habitat.

In the Fraser estuary in the winter months, because of a combination of high precipitation, low water flows, and reduced chlorine treatment, fecal coliform bacteria levels are very high and residues from fuel combustion (PAHs) and electrical equipment (PCBs) are elevated. Fish, such as peamouth chub, show symptoms of exposure to toxic chemicals.

Pollution

Heavy rainstorms create sewer overflows.

FRAP scientists found that municipal sewage treatment and industrial effluents are being better controlled, but that increasingly the main source of urban water pollution is the runoff carried by storm sewers. With continued expansion of the urban footprint, the runoff of oil, chemicals, dust, and fecal material into local water bodies will intensify. Groundwater contamination beneath industrial sites, both operating and abandoned, is also an issue.

Elimination of natural habitat

Urbanization has displaced fish and wildlife from some of its richest waterside ("riparian") habitat and from important wetland areas drained and "recovered" for development. A biodiverse natural habitat in the Lower Fraser Valley has been vital to the abundance and variety of migratory birds on the Pacific Flyway. The loss of such habitat reduces the abundance and variety of migratory species in the region.

Artificial jetties disrupt the balance of the estuary.

River channel management in the Fraser estuary has redirected sediment transport out into the Strait of Georgia, away from the mud and sandbanks of the delta. Scientists suspect some areas, such as in the vicinity of the Tsawwassen and Westshore terminals, have been deprived of sediment replenishment and are therefore eroding.

Urbanization has displaced fish and wildlife from some of its richest waterside habitat

FRAP initiatives

FRAP sponsored initiatives in many areas:

- Habitat conservation: With a number of private and public sector partners, FRAP participated in the purchase of more than 400 hectares of sensitive habitat in the Lower Mainland. The total cost was $9.1 million, of which FRAP's share was $1.3 million. FRAP cosponsored an inventory of surviving sensitive habitat, helped in the designation of protected areas, and supported a variety of stewardship, community, and education projects in support of habitat conservation.

- Air quality: A FRAP-sponsored study found that, over 25 years, the economic benefits of GVRD's air management plan, in the form of reduced medical costs and deaths, will outweigh its costs by billions of dollars. Other FRAP studies investigated economic mechanisms, such as emission trading, as means of implementing environmental policy.

- Non-point sources: FRAP studies analysed the vast and varied contributions of urban activities and smaller industrial sites to pollution, and published guidelines for best practices in environmental management for many sectors. Improvements in the grain loading facilities on the Lower Fraser and Burrard Inlet cut discharges of two pollutant indicators (BOD and TSS) by 95 per cent and 89 per cent, respectively. FRAP worked closely with the Province on the development of a Non-Point Source Action Plan.

- Contaminated sites: FRAP helped sponsor a provincial database of contaminated sites. By 1997, FRAP was actively involved in cleaning up 140 contaminated sites on federal crown land.

JOANNE POTTIER

Smog obscures Mt. Baker: a 'Bad Baker Day' in Vancouver.

AGRICULTURE

Like urban activities, agricultural practices also generate pollution and may degrade or destroy wildlife habitat.

For example, pesticides sprayed on crops get into the groundwater or are washed into nearby watercourses, where they get into the food chain. Manure and commercial fertilizers, especially if overapplied, also pollute the groundwater with nitrates and surface water with phosphate.

Lush streamside habitat has been eliminated.

Farmland, though continuing to support many species of birds, provides a less biodiverse habitat than the natural environment of presettlement times. Wetlands in particular have been drained and converted to farmland. The trees and shrubbery along ponds and streams provide food, cover, and breeding sites for the majority of wildlife in British Columbia. Such riparian vegetation on farms has often been uprooted, banks trampled by livestock, stream beds run through with equipment. Creeks and ponds have often been drained and ploughed, and the stream rerouted.

All these conditions occur in the Fraser Basin. In the Lower Fraser Valley (downstream from Hope) remaining habitats are at risk, and pesticides continue to kill birds. A serious problem is nutrient overloads in most farming areas of the Lower Fraser Valley from mishandling and overapplication of manure. This manure is produced by poultry and livestock farms, which do not have enough land of their own to absorb the nutrients. In the Middle and Upper Fraser Valley, destruction of riparian areas and wetlands by and for livestock is affecting water quality and eliminating vital habitat.

Lower Fraser: fact-finding

FRAP sponsored a variety of research initiatives:

- Water pollution: FRAP-sponsored studies confirmed the presence of nitrates in well water drawn from the Abbotsford groundwater aquifer and were able to trace them primarily to poultry manure. Other studies showed that the Sumas River, in an intensive farming area near the aquifer, contains a variety of pollutants, to the point that frog eggs no longer hatch.

- White haze: FRAP scientists discovered that the white haze that on calm days permeates the eastern parts of the Lower Fraser

Do crops need all this manure?

Valley contains airborne particles incorporating ammonia from manure. Its effects on human health, beyond respiratory difficulties, are not yet known.

Like urban activities, agricultural practices also generate pollution and may degrade or destroy wildlife habitat

• Modelling nutrient pathways: FRAP sponsored a set of studies on manure and fertilization practices among farmers in the Lower Mainland. They found that most areas are producing much higher quantities of manure — often many times more — than crops can absorb, leaving large residues to pollute the water. The oversupply of manure from livestock and poultry is being mishandled, and manure and commercial fertilizers are being overapplied to crops. A shift to non-grain crops needing less nutrition is not being matched by a corresponding reduction in fertilization.

Lower Fraser: initiatives

• Greenfields Program: In the Fraser Delta during the winter, migrating and resident bird species that would have foraged on natural habitat in presettlement times are attracted to the agricultural fields. They eat cash crops and grass intended for pasture, and their feet compact the surface, hampering

THERESA DUYNSTEE

A field readied for winter cover crops

drainage. FRAP cosponsored the Greenfields Program involving delta farmers, residents, and environmental groups to encourage planting of winter cover crops. Such crops provide forage for birds, diverting them from individual farms and cash crops, while reducing soil erosion and enriching the soil.

FRAP cosponsored a program by poultry farmers to truck excess manure to other areas where it is needed

- Agricultural best practices: As in other industrial sectors, FRAP has supported development of best practice guidelines for agriculture, focusing on site-specific evaluations, nutrient and waste management, and habitat management.

- Manure transport and marketing: FRAP has cosponsored a program by poultry farmers to truck excess manure to other areas where it is needed. The program is on the way to its goal of removing 44 per cent of the excess poultry manure produced each year. FRAP also supported an assessment of market

Manure left carelessly in the open causes water pollution.

opportunities for poultry manure, which concluded that a pelleted product for high-end use might be feasible.

• Improved septic systems: A FRAP-sponsored study of alternative septic systems modified to remove nitrogen found several would be feasible. Since installation requires special design knowledge, FRAP cosponsored a workshop on the subject for installers and regulators.

Middle and Upper Fraser

Public awareness is growing about the environmental damage caused by some ranching practices. Livestock operations, feedlots, removal of streambank vegetation, and overwintering of cattle beside streams have been causing water quality and stream degradation problems, as well as loss of riparian and wetland habitat.

FRAP sponsored initiatives were aimed at these problems and included:

• Interior Wetlands Program: With Ducks Unlimited Canada, FRAP cosponsored this program of demonstration projects which combine habitat conservation and improvement goals with water management and sustainable agriculture goals. By 1998, thousands of hectares of wetlands and riparian habitat had been brought into improved management in 23 demonstration projects secured by 30-year agreements with landowners. Successful projects have been featured in brochures and videos. An extensive public education and communications program raises awareness of wetland conservation and sustainable agriculture.

• Community decision-making on water quality: To deal with environmental issues related to agricultural practices and make the needed improvements will require community initiative, commitment, and skills. FRAP cosponsored a demonstration of community-based ecosystem planning in Salmon Arm. The local Salmon River runs through an area of dairy farming, ranching, crop production, forestry, and recreation. For years various citizen groups had been involved in watershed restoration projects. In 1993 the Salmon River Roundtable was formed as an umbrella group to address by consensus the various environmental issues and development problems in the watershed. The project generated a well-organized participatory decision-making process, educated local residents about watershed issues, and supported initiatives, such as the re-establishment of 10 per cent of the riparian habitat along the Salmon River.

A meeting of the Salmon River Watershed Roundtable

FOREST INDUSTRIES

The various branches of B.C.'s largest industry have numerous and significant environmental effects. Logging with its clearcuts and roads can eliminate and fragment habitat, promote erosion, clog streams with debris, and destroy riparian vegetation. Pulp mill effluents are discharged to rivers, and their gases to the air. Lumber mills use fungicides and preservatives that can seep into groundwater or drain as runoff to streams.

GREENPEACE

Anti-sapstain treatment: poor practices

In the last ten years the forest products industry has reduced dramatically the amount of toxic effluent it releases into the Fraser Basin

The industry cuts pollution

In the last ten years the forest products industry has reduced dramatically the amount of toxic effluent it releases into the Fraser Basin:

- Dioxins and furans: By changes to their processes, pulp and paper mills during the 1990s have reduced the amount of dioxins and furans in their effluent by 99 per cent. These chemicals are among the most toxic known.

- Fungicides for softwood lumber: The lumber industry shifted to new fungicides, cut their polluting discharges by 99 per cent, and provided containment to prevent the chemicals from leaking into groundwater and runoff.

KEITH HEBRON

Anti-sapstain treatment: good practices

• Heavy duty wood preservation: The 14 firms in the Fraser Basin that use chemicals such as creosote to protect wood for outdoor use (railway ties, telephone poles, dock pilings) reduced their toxic effluent during 1992–97 by 95 per cent.

FRAP studies confirm that these massive and costly changes have greatly reduced the industry's impact on the waters of the Fraser Basin.

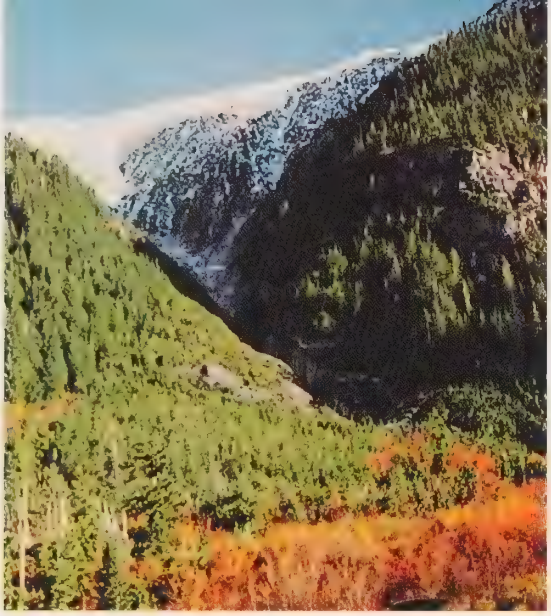
Water pollution from mills

FRAP studies show that effluent from forest industry mills still puts into the water a variety of contaminants. Many of these adhere to sediment particles and have noticeable effects on bottom-dwelling organisms on which fish and birds feed. FRAP studies also show that pulp mill effluents contain substances that promote flocculation (clumping) of sediment particles, which accelerates sedimentation, thus contributing to elevated concentrations of contaminants on river bottoms downstream of mills.

Part of the clean-up of pollution from sawmills involved a shift from the fungicide PCP (pentachlorophenol) to a less toxic substitute, DDAC. However, at sufficient concentrations DDAC turns out to be toxic to fish and plankton, and particularly to the early life stages of sturgeon. Further research is underway.

PETER KRAHN

Recycling lumber treatment chemicals



EC AQUATICS SECTION

Habitat conservation and forest practices

FRAP cosponsored a variety of initiatives aimed at habitat conservation and enhancement in areas affected by forestry:

Studies found that herbicide spraying of deciduous tree stumps reduced biodiversity

- Forest bird habitat: Studies found that herbicide spraying of deciduous tree stumps reduced biodiversity and perhaps even conifer productivity, that riparian habitat is more important to migratory than to resident birds, that 95 per cent of cavity nesting birds rely on trembling aspen, and that two species of woodpecker are responsible for excavating 75 per cent of all the cavities used by other species.

- Encouraging environmentally sensitive forestry: To influence foresters and engage communities, FRAP sponsored operational pamphlets on forest biodiversity issues, biodiversity training materials, a workshop on riparian management, and an educational game for high school students on forestry decision-making.

- Habitat conservation: FRAP worked with provincial land use authorities in the crown land planning processes (CORE and LRMP) to assist in designating protected areas for wetlands, riparian areas, estuaries, and other habitat for migratory birds and endangered species. FRAP cosponsored a remote-sensing project to test the use of satellite imagery to map land use and vegetation cover. The success of the project has led to the mapping process being applied across the province.

EC AQUATICS SECTION

Hairy Woodpecker by its cavity

WHAT'S NEXT

GOVERNANCE

Fraser Basin Council

Fraser Basin Council

The Fraser Basin Management Board, as one of its final acts, issued a Charter for Sustainability, envisaging the Fraser Basin as a place where social well-being is supported by a vibrant economy and a healthy environment. The Charter set the stage for the creation of a Fraser Basin Council, announced in February 1997, with a structure much like that of the previous Board, as a not-for-profit, non-governmental organization with representation from all interests, to continue the practice of shared decision-making.

The Council facilitates and coordinates the use of existing government and non-government authorities

So important was the matter of representation that the Council has 36 members compared to the Board's 19 members. They are drawn from federal and provincial governments, the eight regional districts in the Basin representing 65 municipalities, the eight linguistic and cultural groups among the 96 First Nations in the Basin, the five geographic sub-regions in the Basin, and the business, labour, environmental and social sectors. A neutral Chair presides over the Council meetings.

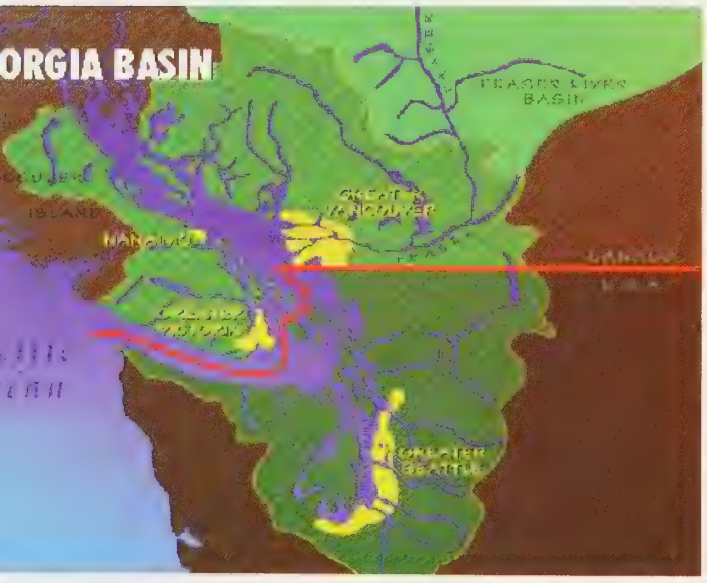
The Council has no direct power but instead facilitates and coordinates the use of existing government and non-government authorities. As the Council builds on the work of the Board that preceded it, gains public support, and develops its own record of accomplishments, its influence will become decisive.

ENVIRONMENT CANADA

Although FRAP funding has come to an end, Environment Canada will continue with its responsibilities and traditional activities in the Fraser Basin. These will include further investigation and action on findings and initiatives supported by FRAP and a continuing commitment to ecosystem-based programs and partnership-building.

Programs will be directed to urban smog problems in the Lower Fraser, non-point pollution in marine and freshwater systems, critical habitats and species, and toxic chemical impacts in the ecosystem. Strategies will include community capacity building, raising awareness and scientific understanding among decision-makers, and exploring more effective governance mechanisms.

Such programs and strategies will be part of the new Georgia Basin Ecosystem Initiative, in which Environment Canada is a partner with other federal departments and with the provincial government.



Georgia Basin: subject of the next Ecosystem Initiative

EC AQUATICS SECTION

RESEARCH AND ACTION

Aquatic science

FRAP-sponsored research, while providing some answers, has raised further questions about pollution in the Fraser Basin that need future attention. For example:

- With the emergence of urban runoff and non-point sources as the predominant pollution mechanism in the Fraser Basin, what are the new contaminants and pathways of concern?
- What is causing the anomalies in fish liver function and pigmentation?
- How dangerous is the new sawmill fungicide DDAC?
- How extensive are the effects of the agricultural pesticides still in use in the Lower Fraser Valley? Will manure management programs restore the Abbotsford aquifer?

EC AQUATICS SECTION

- How are changes in sediment transport affecting the coastline around the Fraser?

- How significant is the threat of pollution if glacier and snowpack melting rates increase?

- Can water quality be protected from the effects of new urban growth?

- Are endocrine-disrupting substances harming fish health?

Aquatic science is moving beyond the investigation of conspicuous individual chemicals to consider more subtle effects of low chemical concentrations and chemical combinations in the ecosystem. This more sophisticated research will be made possible by more sensitive detection capabilities and improved knowledge of chemicals, their pathways and effects.

Climate change presents a second challenge. The effects of climate change could be deeply felt in a mountainous watershed like the Fraser Basin: from the possibility of a rise in pollution levels with increased glacial melting, to changes in sandbars and riverbanks as sediment flow alters, to increased urban runoff contaminating streams or increased stress on agricultural watersheds from irrigation, to the effects on the estuary and delta of rising water levels. These changes, combined with the pressures of rapid urban growth, intensified agriculture, and industrial change, will keep aquatic scientists busy in the Fraser Basin over the next generation.

Peamouth Chub

Starry Flounder

Urban issues

FRAP studies confirm that non-point sources and urban runoff are becoming the main pollution concern in the Fraser Basin. These are connected with urban sprawl and vehicle use and therefore with population growth, which is forecast to be dramatic in the next 25 years, especially in the Lower Mainland.

This will be a different and more difficult challenge than dealing with large and discreet pollution sources like pulp mills

Burbot

Mountain Whitefish

FISHERIES AND OCEANS CANADA

EC AQUATICS SECTION

The Annacis Island Sewage Treatment Plant is being reconstructed to upgrade treatment.

and sewage treatment plants. Addressing non-point sources means dealing with a vast number of small industries and with the general public. It means changing attitudes and behaviours, not just technologies and processes. How progress can be made in these directions has been demonstrated by many FRAP-sponsored programs. A continuing scientific inquiry into the many ecological connections to human and community well-being will play a vital role in persuading people to accept their responsibility to make changes in their use of vehicles, toxic chemicals, and fertilizers.

Good progress has been made in habitat conservation, but the challenge remains

Although recent improvements to sewage treatment plants have reduced pollution from this source to the main river, population growth, particularly in the Lower Fraser Valley, will eventually overwhelm these improvements unless improved treatment technologies are developed and implemented.

Good progress has been made in habitat conservation, thanks in part to FRAP's cosponsorship. But the challenge remains as important as ever:

- A large proportion of natural habitat has already been lost, especially in the Lower Fraser Basin, so that the surviving areas of habitat have become even more critical for wildlife and biodiversity.
- The pressures of urbanization and agriculture on habitat will increase strongly in the next 25 years.

FRAP programs have shown that habitat conservation is popular with the public, can be linked with sustainable forms of urban design, such as Community Greenways, and can mobilize much volunteer labour. This good work must be continued by Basin residents and stakeholders, including Environment Canada.

habitat conservation

Agriculture

The agricultural sector faces growing competition both in markets for its products and for arable land. Farmers face strong incentives to resort to non-sustainable practices for short-term survival. FRAP studies have shown that environmental management is an indispensable part of sustainable agriculture. Basin residents and stakeholders, including Environment Canada, must continue to work with farmers and ranchers on developing best practice guidelines, environmental management plans, and other methods of making decisions on farming practices which are sustainable and friendly to wildlife.

pollution reduction

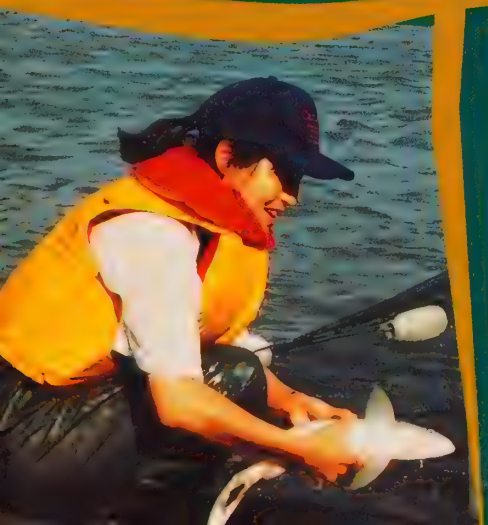
Forest industries

The forest industries face strong international competition at the same time as they are under increasing public pressure to lessen their environmental impacts. In the last decade they have responded vigorously with costly pollution-reduction programs that have brought dramatic results. They have proved that environmentally sound management is consistent with maintaining competitiveness. The industry has developed and is benefiting from a new, cleaner image.

There is need for integrated research on the use of riparian habitat by birds, fish, and small and large mammals. The effects of forest practices on habitat remain controversial. Again, important improvements have begun, but continuing improvement will be required. Much further research on habitat, and the effects of forest practices, will be needed.

Environment Canada | Environnement Canada

Aquatic Science



FRASER RIVER ACTION PLAN

Canada

Additional copies of this report can be downloaded from the FRAP web site (http://www.pyr.ec.gc.ca/ec/frap/index.html) or by writing to:

Environment Canada
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Contents

FRASER RIVER BASIN

RESEARCH DIRECTIONS

The research sponsored by the Fraser River Action Plan (FRAP) has had three broad branches:

- At the centre was a select team of aquatic scientists who assessed pollution in water, sediments, benthic life, fish, and birds throughout the Fraser Basin.
- FRAP also commissioned scientific studies on bird and wildlife habitat: its significance and vulnerability; its reduction and elimination by urban development, agriculture, and forest industries; and methods by which it can be restored, preserved, and managed.
- Finally, recognizing the interconnections between the natural and human environments, FRAP commissioned an array of studies on the economic and social implications, barriers, and opportunities that affect the management of pollution and habitat.

This module outlines the main findings of this seven-year aquatic science inquiry. The studies and findings of the other research branches are presented in other sections.

To tell the aquatic science story, we begin with the Fraser River's headwaters and move downstream to the ocean.

AN UNCONVENTIONAL INSTITUTE

FRAP fostered a collaborative effort of over forty researchers, including Fisheries and Oceans scientists, faculty from University of British Columbia, Simon Fraser University, University of Victoria, and University of Waterloo, and researchers from regional offices of Environment Canada and from the National Water Research Institute and the National Hydrology Research Institute. These researchers were bound by annual workshops, electronic networks, and a common pool of resources. For five years they brought their diversity of expertise to bear on the shared goal of improving our understanding of the Fraser Basin Ecosystem.

With FRAP ended, the researchers have gone on to other work. But their research will be available on the Internet (www.pyr.ec.gc.ca/ec/frap/index.html) through a meta-database and CD ROM containing over 200 technical reports including a bibliography of scientific information.

LAKES

HEADWATER LAKES AS POLLUTION TRAPS

Picturesque Moose Lake near Mount Robson high in the Rocky Mountains seems far removed from human pollution. But its waters revealed to FRAP scientists that lakes commonly regarded as pristine may actually be far from it.

The scientists caught burbot (a freshwater cod at the top of the food chain in such lakes) and sampled their livers. They found toxic chemicals in startling amounts. The burbot livers contained levels of a long-banned insecticide, toxaphene. They also contained very high levels of another banned pesticide, DDT, and of PCBs, which are toxic chemicals found in old electrical equipment and in traces in industrial effluent. These findings were of more than academic concern. Burbot is valued as a sports fish, and burbot livers are favoured as food by some First Nations people.

EC AQUATICS SECTION

Moose Lake

These fish lived undisturbed in a remote mountain lake. The puzzle was: where were the poisons coming from?

Further investigation provided some clues. Significantly absent from the fish livers (as well as from bed sediment deposits), despite the high DDT levels, were correspondingly high DDE and DDD levels, the two break-down products of DDT. This suggested the DDT had arrived recently and had not yet been degraded to any extent. Attention then turned to the water sources for the lake: meltwater from snowfields and glaciers. Scientists around the world were becoming

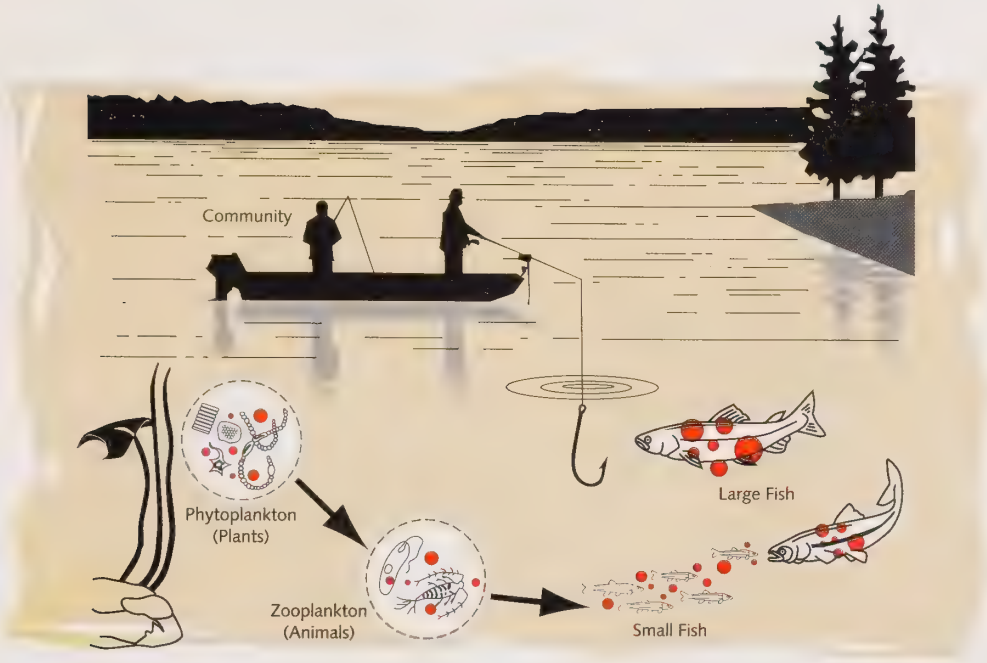
aware of long-range atmospheric transport of pollutants, the ability of contaminants to be distributed globally through the air. Could the DDT reaching Moose Lake have originated in Asia, where it is still in use? DDT was also found in suspended (waterborne) sediments in Fraser River water in the McBride area, downstream from Moose Lake, suggesting that some of it is being carried through the ecosystem.

At Moose Lake, scientists tested sediment cores – vertical columns of lake bottom sediment showing layers deposited over time. The results showed only average "background" levels of PCBs and DDT. This suggested that the high PCB and DDT levels in burbot livers were being caused by biomagnification, which occurs because animal tissues act like filters to accumulate and concentrate the PCBs and DDT ingested in food. These concentrations increase as these animals are eaten by other animals on up the food chain. Burbot, at the top of the food chain, would ingest PCBs already concentrated by its prey – and by its prey's prey – and therefore would accumulate the highest concentrations of all. (Unless, of course, the burbot were eaten by human beings ...)

The scientists caught burbot and found toxic chemicals in startling amounts

Somehow, the PCBs, like DDT, were finding their way into the food chain. It seems most likely that they are carried globally by the atmosphere, descend into the snowfields and glaciers with precipitation, and are then released into the ecosystem in meltwater.

Even pristine locations can't escape global atmospheric pollution.



The food chain concentrates pollutants.

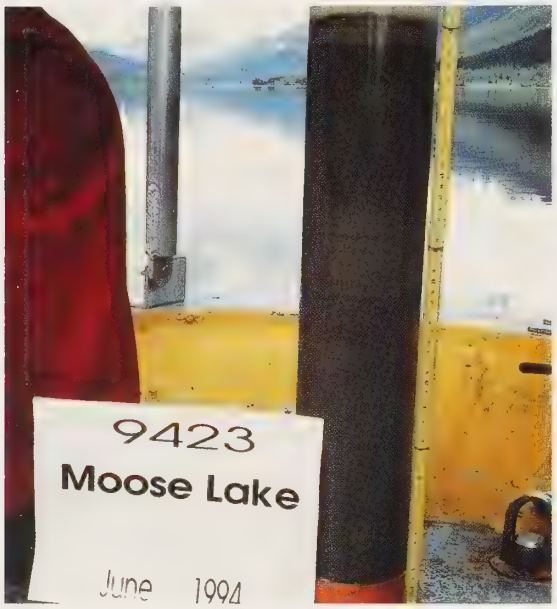
Toxaphene presented a similar riddle. There is no historic record of its concentration levels because it doesn't adhere to sediment particles very well and so does not show up in sediment cores. But it does bioaccumulate readily, so even small amounts in water can lead to surprising concentrations in fish. But how did toxaphene get into the water, because it has not been used in Canada or the United States for many years? Scientists suggest that it too probably comes from another continent, carried by the winds and deposited by rain and snow in our watersheds.

Glaciers and snowfields act as first-tier traps for contaminants arriving by air

Atmospheric sources are also suspected for contaminants found in Stuart Lake, near Fort St James, and in Chilko Lake, on the inland side of the Coast Mountains. Research shows that fish in headwater lakes tend to have higher contaminant levels. Scientists suspect that, just as glaciers and snowfields act as first-tier traps for contaminants arriving by air, so the headwater lakes into which the meltwater flows act as second-tier traps, where contaminants that adhere to sediments can be deposited in the lake bed. If so, lower regions in the watershed are being protected from contamination by these high-altitude barriers. The "pristine" mountain lake may be just the opposite: a protective but contaminated reservoir. British Columbians can no longer regard their environment as isolated from polluted regions of the world.

There is a link here to global warming. As awareness grows of the global atmospheric distribution of pollution, climate change acquires a special significance in mountainous watersheds like the Fraser Basin.

Accelerated melting of glaciers and snowfields could speed up the release of their long-gathered store of contaminants into the headwater lakes, raising the levels of toxic pollution downstream.



ROB MACDONALD

A Moose Lake sediment core in which contaminants were found

FRAP findings indicate that a chemical may continue to contaminate long after it is banned

OTHER POLLUTANT SOURCES

Another kind of contaminant source was suggested by findings from similar sampling in Nicola Lake, near Merritt in the Thompson watershed. Testing of sediments and burbot livers indicated that the lake has low levels of most contaminants, with the surprising exception of DDT. An atmospheric pathway seems unlikely, because the concentrations of other related contaminants (known as "organochlorines") should also be elevated, but they are not. Moreover, the lake is situated in a relatively dry area of the province and is not surrounded by a big catchment system of mountains and snowfields. Yet the data indicated that a release of a large amount of fresh DDT occurred in the lake relatively recently, some time between the late 1970s and the mid-1980s, at least ten years after DDT use was banned in Canada. There is suspicion that, after DDT was banned, some stocks were illegally used or dumped.

In any case, these FRAP findings indicate that a chemical may continue to contaminate the environment long after its use has been banned.

Sediment cores from Stuart Lake show the historical cycle of mercury contamination from mine tailings dumped into Pinchi Creek upstream during the Second World War. At one time, mercury contamination spread throughout the lake. It has declined only gradually, and a half century later has still not quite returned to normal levels. A similar historic pattern is revealed for PAHs, a byproduct of combustion, in Harrison Lake adjacent to urban, agricultural, and industrial regions in the Lower Fraser Valley. Scientists believe that PAH levels reflect not only fossil fuel combustion in vehicles but also local slash burning and beehive burning of wood waste. Sediment layers show PAH accumulations beginning in the 1890s and rising to a peak in the 1950s, when coal began to give way to petroleum products as fuel. Since then, PAH contamination in sediment core layers has decreased somewhat.

SEDIMENT

MOVEMENTS

The Fraser River shifts sediment into the ocean at an average rate of one metric ton (2200 lbs) every two seconds. This rate is equivalent to the weight of the Titanic every day. In years of high flow, the delivery can double. This sediment, suspended in the waterflow, can be seen from aloft as a brown plume pushing from the arms of the Fraser out into and across the Strait of Georgia. Sediment that did not make it all the way to the sea (at least not yet) has settled and gradually filled the wide fertile bottom of the Lower Fraser Valley and spread out to form the delta (floodplain) and estuary (tidal reaches).

Throughout the watershed, streams and rivers scour their banks and pick up sediment, which consists of particles of coarse sand, fine silt, smooth clay, and organic material. The particles are carried downstream in suspension for distances that vary with their size, and then settle out, the heavier particles first. Later, when the flow increases, they may be lifted and carried again. The currents, scouring and eddying, lifting and depositing, sculpt the river bottoms and banks into shapes that change with water levels and current velocities.

Much fine sediment is stored seasonally in the riverbed or in sand bars along the channel bank through much of the river's length. Then, during seasons of exceptionally high flow, several years' worth of stored sediments may be carried off.

In the Fraser estuary, not all sediment transport goes downstream. FRAP scientists have observed upstream movement of sediments in some channels carried by flooding tides. A net flow of sediment up the Pitt River has produced a reverse delta at the mouth of Pitt Lake. In some areas that have been dredged (eg Queen's Reach near New Westminster and Main Arm by Steveston Cut and Steveston Jetty), some scientists suggest there are signs of an upriver return of sediment quantities removed by dredging. This would support the general observation that sediment configurations on river bottoms are developed into a state of equilibrium over time and tend to re-establish themselves when disturbed. Some observers argue that the use of sandy dredged sediment for construction may be effectively starving the delta.

The Fraser estuary has been shaped and has in the past been maintained by continuing deposition of silt as the river flow interacts with tidal currents. But this natural process has been curtailed and may have ceased. Studies show that dikes, training walls, and dredging have channelled the arms of the Fraser and redirected flows and sediment transport. Only at tiny Canoe Passage, a channel too small to have been altered and accounting for only 5 per cent of the total Fraser flow, can natural deltaic processes still be seen. The intertidal flats of Roberts and Sturgeon banks show signs of sediment depletion. Evidence of erosion in the vicinity of the Westshore and Tsawwassen terminals warns of possible long term threats to those structures.

The Westshore marine terminal at Roberts Bank

CONTAMINANT TRANSPORT

Apart from large-scale physical alterations in shoreline, delta, and estuary habitats, the main significance of sediment movement for FRAP is as a carrier of pollution. Many contaminants adhere to sediment particles and therefore are carried with them. When sediments settle and build up gradually into deep stable layers, as in lake and ocean bottoms, they eventually sequester the attached contaminants, removing them from the biosphere and providing sample cores with the historic record of depositions. But when sediments are scoured and move, they bring contaminants with them.

Sediment deposits in rivers are good indicators of recent contaminant exposure

Sediment deposits in rivers are good indicators of recent contaminant exposure, especially for contaminants that are insoluble in water. Moreover, sediments are sometimes regarded as better indicators of pollution sites than fish or wildlife because of the predictability of their movement with the streamflow.

Contaminants adhering to settled sediments, instead of being sequestered in the slow layering of the bottom, may be diverted into the food chain. The upper layers of sediments are the habitat of algae and bacteria, which become food for benthic (bottom-dwelling) organisms, such as shellfish, worms, and insect larvae, which are in turn eaten by fish and birds. In this pathway, the contaminants enter animal tissues, where some accumulate and are biomagnified with each step. Scientists found these benthic organisms to be excellent indicators of environmental disturbance.

Unless they are directly and acutely toxic, pollutants usually do more damage by entering the food chain, with its biomagnifying

power, than by remaining suspended in the water. Contaminated sediments are a pathway leading water pollutants into the food chain and therefore into fish and birds (and humans) at harmful concentrations. For this reason, scientists paid close attention to the tendency of sediments to be deposited or to remain suspended.

Since larger particles settle out more quickly and smaller particles remain suspended longer due to their dynamics, anything that makes particles larger will increase the rate of deposition. One thing that does this is a tendency for particles to flocculate (clump), which increases a particle's mass more than its surface area. Scientists found that pulp mill effluents contain substances that encourage flocculation. Suspended sediment samples collected upstream of pulp mills had a higher proportion of single particles, while samples from downstream had a higher proportion of clumped particles. These clumped particles were more likely to settle to the riverbed sooner, especially in the low flows of winter. Laboratory tests showed that flocculation increases the rate of deposition by up to 30 per cent. These effluents therefore not only add pollutants to the river but also, by encouraging flocculation, help them reach benthic organisms.

EC AQUATICS SECTION

A centrifuge used for studying sediments

BENTHIC ORGANISMS

Animals living in the sediment on streambeds and lakebeds can be subdivided between vertebrates (having a backbone) and invertebrates (lacking a backbone). The invertebrates can be arbitrarily subdivided further between macro (big) and micro (small), with the dividing line being visibility to the naked eye or, scientifically, at 0.4mm. The macroinvertebrates were the ones most useful to FRAP's scientists, because they can be easily netted, identified, and counted. They range in size from clams and crayfish down to wormlike and buglike insect larvae and beetles. FRAP scientists also made use of algae and bacteria, which form visible groups or colonies.

BENTHIC ORGANISMS AS ENVIRONMENTAL INDICATORS

Bottom-dwelling organisms are an important point of entry for contaminants into the food chain. Since they don't move around like fish, they can represent conditions at a particular location. They would be useful indicators of exposure to pollution, except for the difficulty of collecting the large number of individual organisms needed to make a reliable sample.

Nevertheless, scientists developed two innovative ways to use benthic organisms as environmental indicators. The first way focuses on the relative abundances of

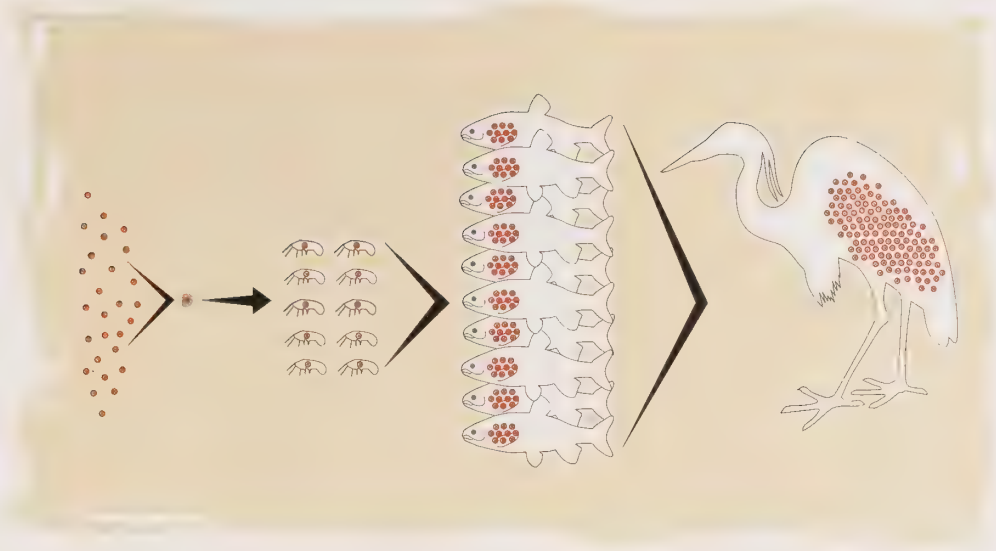
Bottom-dwelling organisms are an important point of entry for contaminants into the food chain

macroinvertebrate populations. By extensive research, scientists developed a model of the species composition expected in a healthy community under specified conditions, such as rock size, stream width, water velocity, stream gradient, altitude, and water conductivity and acidity. This model allows researchers at a particular location to measure these conditions and predict the relative species abundances if the community were healthy. They can then collect samples of bottom sediment at a selected site and count the species and numbers they actually contain.

Differences between expected and actual populations indicate disturbances at the site such as pollutants in water and sediments.

For example, an examination of numerous Fraser Basin sites with this model revealed five locations with signs of benthic disturbance. Scientists were able to propose probable causes. At Guichon Creek in the Thompson Basin, the likely cause was mine drainage. On the Salmon River near Salmon Arm, disturbances were attributed to agricultural activities. At sites in the Bowron, Torpy, and Tyaughton watersheds, disturbances were linked to habitat disruption from logging.

The second method of measuring pollution uses an experimental approach in a device called a mesocosm ("mid-sized world"). Essentially an artificial stream in a tank, the mesocosm allows organisms in samples from river bottoms to be exposed directly to effluents at different controlled concentrations. After three weeks, the organisms in a mesocosm are removed, identified, counted, and weighed. These features are compared to those of a parallel set of organisms from the same sample (the sample was split) which were placed as a control group in another mesocosm and



Contaminants become more concentrated with each step up the food chain.

exposed to water drawn straight from the river. The differences in species, numbers, and total weight (biomass) between the control group and the effluent-exposed groups indicate the effects of the various exposure concentrations on organism survival and growth. The mesocosm can also be used to determine how different effluent concentrations affect the rate of growth of algae and bacteria colonies on clean rocks.

In FRAP's case, eight mesocosm tanks and their associated plumbing were mounted on a flatbed truck, which could be moved to a site of interest. In this way, industrial effluent, for example, could be tested under varying degrees of dilution. Mesocosm tests were used to show the effects of dilution on standard pulp mill effluent. At a 1 to 3 per cent effluent-to-water ratio, a dilution found in low-flow conditions, benthic biomass shows unusual growth compared to the control population. At about 3 per cent, extra growth ceases. At 5 per cent and higher, symptoms of toxicity begin.

Although benthic organisms can be used to detect and measure contamination in these ways, such tests do not identify the contaminants involved. But careful monitoring of variables such as dissolved oxygen, acidity, temperature, and selected contaminants can help scientists narrow the list of possibilities.

mesocosm

A mesocosm in operation

Left–An enlargement of a benthic invertebrate: a Water Boatman


FC AQUATICS SECTION

FISH

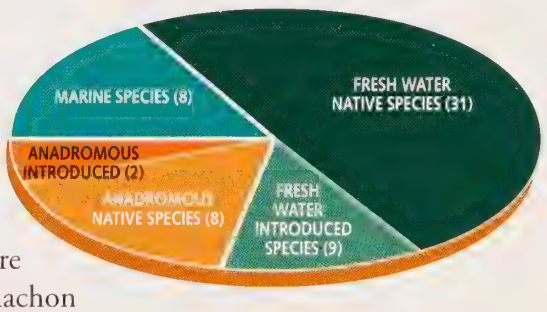
SPECIES AND DISTRIBUTION

Most studies of fish in the Fraser Basin have been confined to salmon and trout, the species important to commercial and recreational fishing. Little was known about other resident species. A FRAP project therefore drew together published and unpublished records to make an atlas showing the distribution of all species in the Basin.

Half the species disappeared from Wright Creek near Prince George

The atlas showed that the Fraser watershed has 58 fish species in all: 40 freshwater species (31 native and 9 introduced), 10 anadromous species (8 native and 2 introduced), and 8 marine species that enter the river regularly. Eight species are found only downstream of the Fraser Canyon, and 7 are found only upstream of the Canyon (some ranging only to the junction with the Bowron River, around the curve from Prince George). Only 10 species are found throughout the Basin: mountain whitefish and peamouth chub (which were selected as indicators partly for their wide distribution), white sturgeon, and some trout and salmon species.

Scientists found evidence of decline in some species in some areas of the basin over the last 30 years. One study concluded that, from the 1960s to the 1990s, half the species disappeared from Wright Creek, a tributary of the Salmon River near Prince George, and that the disappearing species required cool, clear water. Other studies inferred similar reductions in species in Lower Fraser Valley tributaries and probably in the Thompson system as well. It is believed that some disappearances were due to overfishing, but that habitat degradation and exposure to contaminants were more often to blame.



Loss of species has not been recorded in the main stem of the Fraser. But some species are in trouble. Eulachon (also called oolikan) and white sturgeon have been severely reduced in numbers. The sturgeon has been listed as "vulnerable" by the Committee on the Status of Endangered Wildlife in Canada and is no longer fished commercially. The Salish sucker has declined so dramatically that it is listed as "endangered."

CONTAMINANTS IN FISH

Mountain whitefish and peamouth chub were selected as the main fish indicators for contaminant research. They are found throughout the Basin; they live long enough to accumulate measurable quantities of pollutants; they feed primarily on benthic organisms; and mountain whitefish usually stick to the same summer foraging sites.

FRAP's studies raised many questions. Scientists were unable to show a clear relationship between fish condition and contaminant exposure – to demonstrate that the pollution harmed the fish. Both chub and whitefish were found to be in the best condition and size for their age in the Nechako, Thompson, and Lower Fraser. Yet fish in the Thompson and Lower Fraser are exposed to some of the highest cumulative levels of contamination in the Basin. Scientists attributed the good condition of the fish in these reaches to their having better food sources, as a result of higher temperatures in all three and clearer water as well in the Nechako and Thompson.

Fish health assessments were even less conclusive. For three years (1994–96), scientists tested fish using a health assessment index composed of a set of measurements

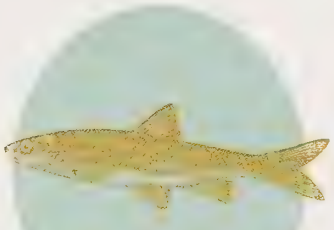
NEW CONTAMINANTS CONTINUE TO EMERGE

The peamouth chub swims throughout the watercourses of the Fraser Basin. Like the mountain whitefish, it was used by FRAP scientists as an indicator of contamination in the basin's rivers and streams. When scientists examined female chub taken from the lower reaches of the Fraser, they found, as expected, a blood protein known as vitellogenin, indicating the presence of female hormones. But they also found vitellogenin in male fish taken from the same reaches. They hypothesized that some estrogen-like chemical was causing the males to produce it.

Scientists concluded the fish were being exposed to endocrine-disrupting chemicals (EDCs), substances that can enhance or counter the effect of natural hormones that are essential for many bodily processes in animals and fish. There is concern that EDCs can lead to cancer, decreased fertility, and birth abnormalities.

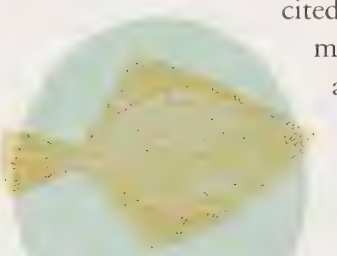
EDCs have been traced to pesticides such as DDT, to additives that make plastics flexible and soft, to wetting agents in detergents designed to help water penetrate fabrics, and to natural and synthetic estrogens such as those found in birth control pills. EDCs are widely used and may produce effects at very low concentrations.

Male peamouth chub taken from the estuary in July 1996 showed concentrations of vitellogenin four times higher than chub taken elsewhere in the basin. Yet fish taken from the estuary two months later showed no elevated levels of the chemical.

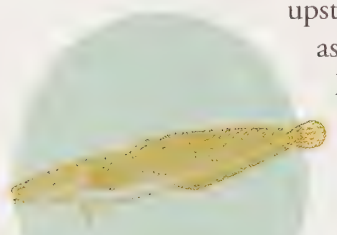


Peamouth Chub

of selected characteristics, such as liver pigmentation. Significant variation was noted, and again there was no consistent relation between contaminant exposure and health as measured by this composite index. One study using this technique in 1993 and 1994 cited a high incidence of abnormalities in Lower Fraser fish and ascribed it to human activities. However, FRAP research, using similar data but covering a larger geographic area, found no higher incidence of abnormalities in the Lower Fraser than in other parts of the Basin. Abnormalities are common, but they seem to be evenly distributed, as frequent upstream from major urban areas as downstream from them. Researchers believe the abnormalities are probably caused by factors other than pollution, such as physical conditions in the main stem river (high flow, high suspended sediment content) or cycles of parasitic infection.

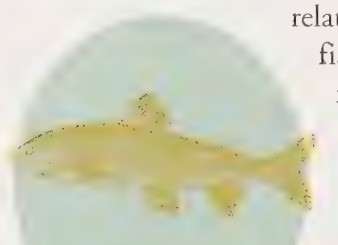


Starry Flounder



Burbot

An observation that might be related to contamination is that fish downstream from pulp mills at Woodpecker and Marguerite have highly pigmented organs. This finding is supported by a similar study on the Columbia River.



Mountain Whitefish

FISHERIES AND OCEANS CANADA

FRAP research shows that since the 1970s and 1980s there have been decreases in fish tissue concentrations of certain contaminants on which action was taken. Declining contaminants include PCBs (which have been banned), lead (which has been removed from gasoline), arsenic (following the closing of a copper smelter in Tacoma), and mercury (following industrial process changes). Dioxins and furans have decreased following changes in pulp mill effluents.

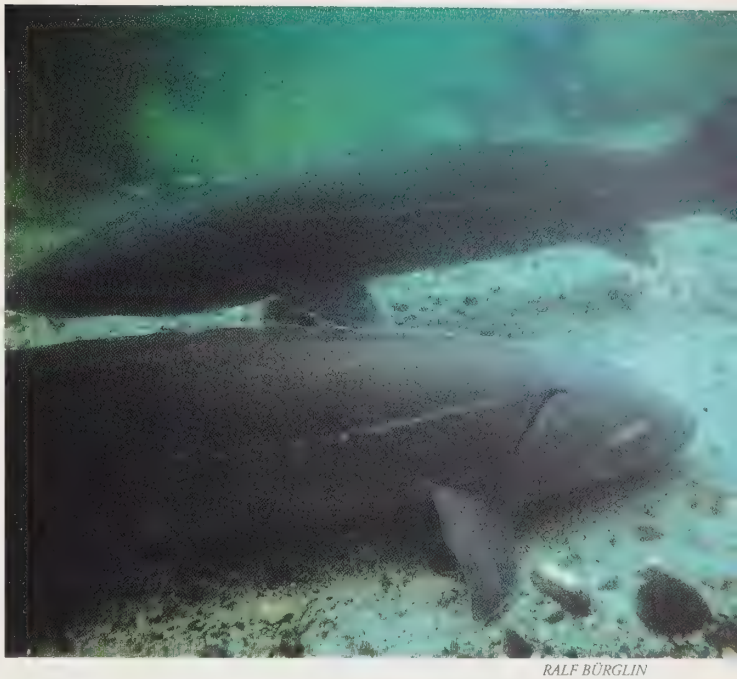
Yet symptoms in fish continue to indicate likely contaminant exposure. For example, contaminant stress was observed in tests on the levels of mixed function oxygenases (MFOs), enzymes produced in fish livers to remove toxic organic chemicals. The MFO levels in peamouth chub and mountain

FC AQUATICS SECTION

A Peamouth Chub

whitefish varied consistently with observed organic chemical levels in fish tissue and in sediment where the fish were found. The MFO induction could not be traced to any specific chemical, though the correlation between MFOs and traces of dioxins, furans, and PCBs in mountain whitefish liver was considered statistically reliable. Nevertheless, MFO induction in fish livers provides a warning of organic contaminant exposure in the environment. And in the Fraser Basin this particular alarm is sounding.

Some chemicals in industrial use are indeed highly toxic to some life stages of some species. DDAC, recently introduced as an ingredient in anti-sapstains (anti-fungicides used to prevent discoloration of new lumber), has been shown to be very toxic to early life stages of sturgeon (40- to 60-day old fry), though other species, such as the starry flounder, common to the Fraser estuary, are much less affected by the chemical. But the pathways taken by pollutants affect species' exposure. During high flow periods DDAC disappears very quickly from the water because it binds readily to particles. Some



RALF BÜRGLIN

Around for eons, Sturgeon are found throughout the Fraser, may live 100 years, and may grow to six metres.

Some chemicals in industrial use are indeed highly toxic to some life stages of some species

areas in the estuary may therefore be toxic to some organisms because of the accumulation of DDAC in sediments deposited there. The toxicity of sediments exposed to DDAC is still being studied.

DDAC is an example of the continuing challenges posed by technological change. It was welcomed as a much less toxic substitute for PCP (pentachlorophenol), a traditional anti-sapstain chemical. The much higher cost of DDAC has had the additional advantage of stimulating its conservation and reuse, greatly reducing releases to the environment. But concerns are reappearing as scientists begin to take a closer look at the effects of this new chemical. For example, DDAC has not been studied enough to derive sediment-concentration standards.

Much attention is focused on the toxicity assessment of DDAC on the Lower Fraser, where the chemical is mainly used. The lumber industry is very concerned about further restrictions on the use of a chemical on which it relies heavily. There are many interested parties watching the results of further toxicity testing on DDAC, now the third most-used pesticide in the province.

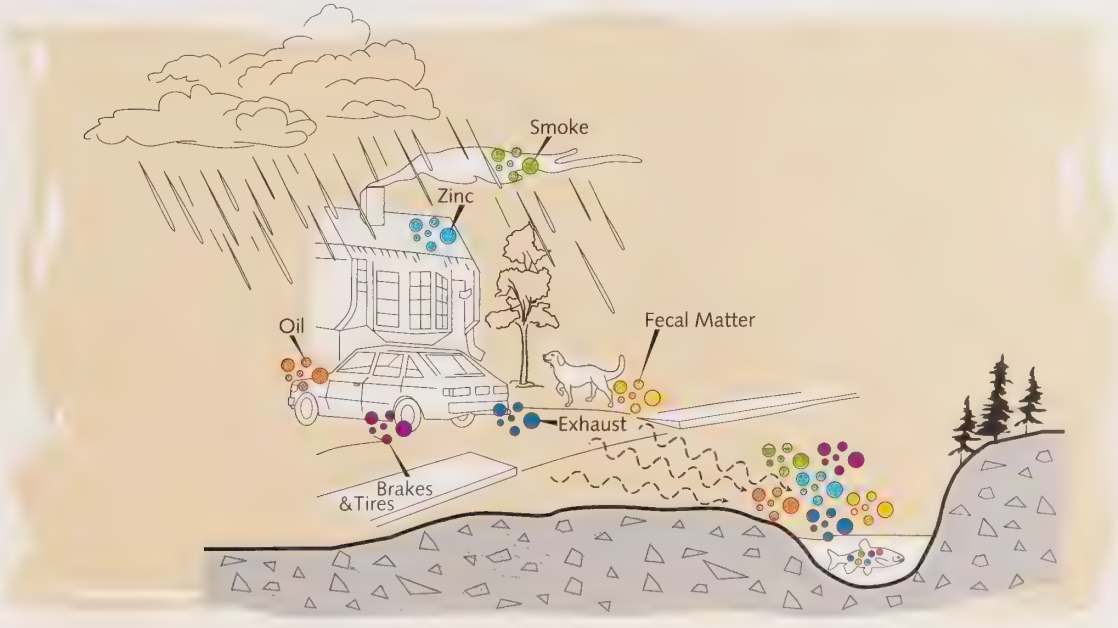
POLLUTION SOURCES

The findings of FRAP scientists suggested that pollution in the Fraser River system comes mainly from urban runoff, agricultural activities, and the forest products industry.

URBAN RUNOFF

The paved surfaces and roofs in cities and towns collect precipitation and direct it into storm sewers, through which it drains into watercourses. On the way, the rain or snow gathers contaminants from gases and dust in the air, from roofs, streets, and gutters, and carries them with it, especially in the first wash of rain after a dry spell.

Lakes and streams in urban areas become degraded by this pollution flowing into them. The contaminants often include coliforms (fecal bacteria), metals, and a wide variety of carbon compounds associated with fossil fuel combustion, in vehicles, furnaces, barbecues, and so on. Elevated concentrations of dioxins, furans, PAHs, and metals are measured in urban watercourses and suspended sediment during rainstorms. PAHs and metals deposited from the air also are washed into urban streams by rain. During storms, copper, zinc and sometimes lead frequently exceed water quality objectives.



By studying layered sediment in cores taken from Burnaby Lake, in the urban Brunette watershed, FRAP researchers determined that some kinds of contamination are declining. Loadings of PCBs and DDT have decreased from their peaks in the 1950s and 1960s. Both fish and sediment show a decrease in lead levels compared with the 1970s and early 1980s, declines that coincided with the gradual elimination of lead as a fuel additive.

EC AQUATICS SECTION

Lakes and streams in urban areas become degraded by pollution flowing into them

Bottom-dwelling species in the lakes and streams of the Brunette Basin tend to be less sensitive than others to heavy metal contamination, indicating that metal toxicity is eliminating sensitive species and influencing the composition of the underwater communities.

In the Brunette Basin, where city traffic is heavy, much of the pollution comes from vehicles. Though some improvement has occurred, such as with the removal of lead from gasoline, urban stresses continue. In the region as a whole, the human population is projected to grow strongly, and the use of vehicles is projected to increase faster than the population. Even the quality of the Fraser River itself is being affected by the urban development through which it flows: there are elevated levels of PAHs in the water, in estuary sediment, and in estuary fish.

AGRICULTURE

FRAP scientists found evidence that water quality in the Sumas River, and its tributaries in the Lower Fraser Valley, is affected by agricultural practices. In surface waters they measured low levels of oxygen and elevated levels of nitrates, ammonia, phosphorus, and coliforms. In surface waters as well were high levels of zinc and copper, for which hog feed was considered a likely source. Elevated levels of nitrates were also found in groundwater. Frog's eggs would not hatch in some areas of the central Sumas Basin even though habitat there appeared acceptable.

To the south, some toxicity was detected in sediments at the international boundary with the United States, but it was not clear that agricultural practices are to blame. The area is also affected by City of Sumas (Washington) sewage treatment plant discharge, and there are high levels of nickel and chromium in the area from geological sources.

FOREST INDUSTRIES

Dramatic declines in dioxin and furan levels have been measured since the 1980s when the pulp and paper industry, prompted by public concerns and tighter regulations, began to change its bleaching processes. Declines in anti-sapstain chemicals and heavy duty wood preserving chemicals used by the lumber industry have been almost as impressive.

FRAP monitoring has shown that the effect of pulp mill contaminants on ospreys is decreasing. From 1992 to 1997, the difference between higher osprey fledgling success upstream from pulp mills and lower success downstream has narrowed to the point where they can no longer be distinguished.

Effluent quality is much better, but challenges remain.

Dunlin BRETT SANDERCOCK

POLLUTION IN THE FRASER ESTUARY

FRAP researchers examined the ecology of the delta foreshore – Sturgeon and Roberts Banks – to look for indicators of exposure from contaminants, and to establish the current condition of Sturgeon Bank. Until 1988 Vancouver's major sewage outfall (from the Iona Island treatment plant) released its effluent onto the intertidal flats, causing obvious degradation.

Since the Iona Island outlet pipe was extended, moving the outfall location into the Strait beyond the estuary, Sturgeon Bank has been recovering. Life has returned to the former outfall point. Invertebrates are becoming dense again, and algal populations have changed from blue-green or green algae (usually indicative of polluted

DUNLIN

The vast intertidal flats of the Fraser estuary, from Iona Island to Boundary Bay, provide critical habitat for millions of migratory and overwintering shorebirds that feed on marine invertebrates. What, and how well, they eat are vital factors in their survival and success in breeding. But little is known about their feeding habits.

As a migratory bird that spends half of every year on the delta, the dunlin seemed a possible candidate to show the effects of exposure to contaminants on the sand flats. FRAP scientists watched the little bird with the long, thick bill, observing its feeding habits.

The dunlin foraged both day and night, as expected. But researchers were surprised to find that after dark it often left the flats for nearby agricultural fields. Perhaps the prowling falcons kept it away from the fields during the day. Or maybe there was something in the fields it preferred. Researchers don't know.

Furthermore, they found that on the sand flats the dunlin eat prey that is lower on the food chain than they had expected, so its exposure to contaminants could be very low.

The scientists decided they would have to learn more about the dunlin's habits before they could use it to interpret the effects of estuary pollution.

At Iona Island, the sewage outfall has been extended to deep water.

conditions) to silica-walled diatoms, as found in other areas of the banks.

Until 1988, Vancouver's major sewage outfall released its effluent onto the intertidal flats

Sediment concentrations of metals have remained constant or decreased. Tests of the intertidal clam Macoma have shown reduced concentrations of copper, mercury, and zinc.

Sediment tests have confirmed reduced concentrations of copper, lead, silver, mercury, and cadmium. Oxygen concentrations in overlying waters have risen, though nitrate, nitrogen and ammonia levels are still relatively high because of the high concentration of organic carbon still in the sediments.

The contaminated sediments still stimulate an unnatural amount of algal growth on Sturgeon Bank, especially during the summer. But it is hoped the supply of nitrogen will decline to "natural" levels once occasional sewer overflows stop and the organic matter accumulated from 24 years of sewage discharge is finally decomposed.

INDICATORS OF ECOSYSTEM HEALTH

Since a FRAP objective was to measure the ecosystem health of the Fraser Basin, scientists had to select health indicators. Their focus was on the effects of pollution, and their choice was influenced in part by the indicators previously used in the Basin, for which long-term data were available on contaminant exposure. At the same time, the scientists explored new species and sampling methods to address newer pollution issues and to use the latest technologies.

In this enterprise, scientists gained some valuable insights into the merits and the disadvantages of different techniques for assessing ecosystem health. Their findings about the relative merits of, for example, sediments, benthic organisms, fish, and birds as indicators of contaminant levels, and about the value of using certain natural populations as indicators of ecosystem health, will be used to focus future monitoring efforts.

EC AQUATICS SECTION

EC AQUATICS SECTION

WHAT'S NEXT

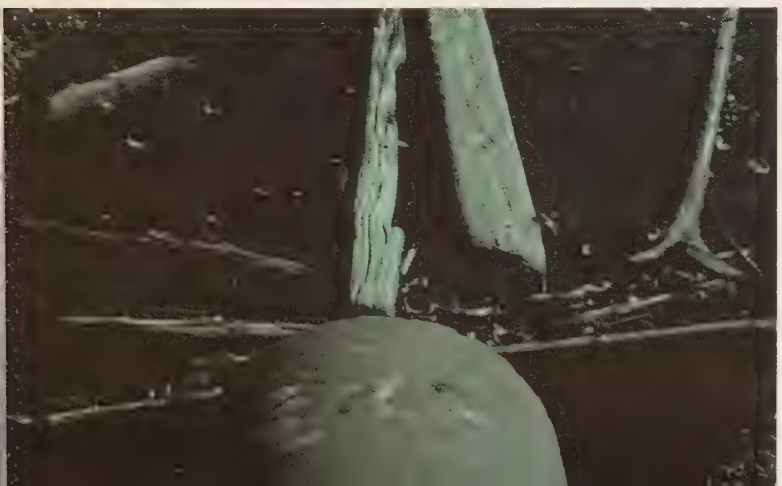
RESEARCH QUESTIONS

FRAP-sponsored research, while helping settle some matters, has raised further questions about pollution in the Fraser Basin that need future attention. For example:

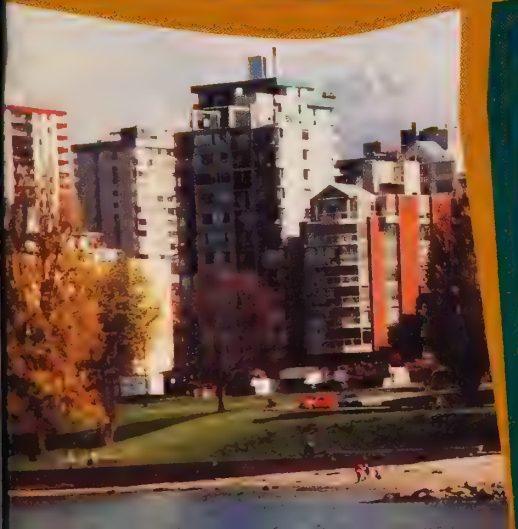
- With the emergence of urban runoff and non-point sources as the predominant pollution mechanism in the Fraser Basin, what are the new contaminants and pathways of concern?
- What is causing the anomalies in fish liver function and pigmentation?
- How dangerous is the new anti-sapstain fungicide DDAC?
- How extensive are the effects of the agricultural pesticides still in use in the Lower Fraser Valley?
- Will manure management programs restore the Abbotsford aquifer?
- How are changes in sediment transport affecting the coastline around the Fraser?
- How significant is the threat of pollution if glacier and snowpack melting rates increase?
- Can water quality be protected from the effects of new urban growth?
- Are endocrine-disrupting substances harming fish health?

Aquatic science is moving beyond the investigation of conspicuous individual chemicals to consider more subtle effects of low chemical concentrations and chemical combinations in the ecosystem. This more sophisticated research will be made possible by more sensitive detection capabilities and improved knowledge of chemicals, their pathways and effects.

Climate change presents a second challenge. The effects of climate change could be deeply felt in a mountainous watershed like the Fraser Basin: from the possibility of a rise in pollution levels with increased glacier melting, to changes in sandbars and riverbanks as sediment flow alters, to increased urban runoff contaminating streams or increased stress on agricultural watersheds from irrigation, to the effects on the estuary and delta of rising ocean levels. These changes, combined with the pressures of rapid urban growth, intensified agriculture, and industrial change, will keep aquatic scientists busy in the Fraser Basin over the next generation.



Urban Issue



FRASER RIVER ACTION PLAN

Canada

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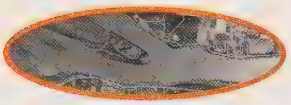
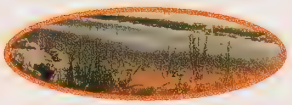
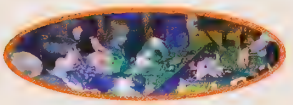






FRASER RIVER BASIN

CITIES AND THE ENVIRONMENT

Urban areas intrude into and interact with the natural environment in innumerable ways. The Fraser River Action Plan (FRAP) focuses on interactions which are critical to the fish and wildlife of the Fraser River watershed.

For a few fish and wildlife species an important interaction with urban residents has been hunting and fishing for recreation or commerce. However, the focus of FRAP's attention has been other subtle and dangerous byproducts of urban activity. These are of two kinds:

- elimination of natural habitat: land use and watercourse alterations reduce and eliminate diverse natural forms of space, shelter, and food for fish and wildlife.
- pollution: contaminants are discharged into the water and air, which carry them into harmful contact with fish and wildlife.

FRAP programs have investigated the issues and taken action in both these areas.

EC AQUATICS SECTION

Streams in cities are under increasing environmental pressure: Brunette River, Burnaby.

ELIMINATION OF NATURAL HABITAT

Cities often grow in locations rich in diverse natural habitat. The shorelines and river banks that appealed to pioneers and later settlers in British Columbia are also favoured by wild animals and birds. As settlements grew into towns and then into sprawling cities, wildlife has been progressively excluded from some of its best habitat. Housing, industrial developments, and transportation corridors squeeze and divide natural populations. River docks and shoreline structures

push into the backwaters and shallows that make prime fish habitat. Of 30 creeks historically recorded in the city of Vancouver, only one still runs freely. There has been little in past urban design to encourage human cohabitation with fish and wildlife.

Human encroachment may accelerate. In the next 25 years, city populations in the Fraser Basin are expected to grow dramatically.

In the next 25 years, city populations in the Fraser Basin are expected to grow dramatically

For example Greater Vancouver is projected to grow by 51 per cent, Kamloops by 48 per cent, and Prince George by 33 per cent. New residents and businesses will intensify the pressures on the landscape.

As will be seen, FRAP's initiatives have included conservation and rehabilitation of surviving riparian (waterside) habitat and wetlands. In the Fraser delta alone these areas remain vital to migration staging, breeding, and overwintering of more than 1 million shorebirds and about 250,000 waterfowl annually.

POLLUTION

Cities and towns expose fish and wildlife to waterborne pollution in a variety of ways:

- Effluent: Water is used by residents and industries and then discharged, with varying degrees of treatment, into watercourses as "effluent." Effluent discharges from municipal sewage treatment plants and from industrial outlets are "point sources" which are licensed, monitored, and subjected to regulations for effluent quality. Municipal sewage contains chemicals, not only from residential products such as household cleaners, solvents, and laundry detergent but also from the smaller industrial firms that do not have their own effluent treatment, but rather are connected to the municipal sewer system.

- Runoff: The rooftops and paved surfaces of urban areas act as a vast collection system for precipitation. Unlike the countryside, which holds precipitation in vegetation or allows it to percolate slowly through the soil, these hard urban surfaces channel it immediately into storm sewers, which carry it directly into watercourses. When rain follows a dry spell, the first pulse of runoff lifts the load of dust, oil, litter, and chemicals

which has accumulated in gutters and streets and washes it into the river. Some storm sewers share a discharge system with sanitary sewers. During wet weather, heavy runoff can overload the combined sewer system and impair sewage treatment. When this happens, in an event known as a combined sewer overflow, or CSO, untreated sewage may join the quantities of stormwater flowing into the receiving waters. The origins of runoff pollution, such as leakages of oil from cars and trucks or airborne contaminants caught in the rain, often called "non-point sources," are too numerous to identify and control individually.

• Contaminated sites: A location where a polluting activity was once carried on, such as certain abandoned industrial sites, may be underlain by a residue or plume of toxic chemicals. With the movement of groundwater, these chemicals may slowly drain into surface waters. More than 1600 such sites have been identified throughout the Fraser Basin, and not only in urban areas. There is no reason to believe that all have been found.

The relative importance of these categories is not entirely clear. Point source effluents are comparatively well known. Much less is known about runoff pollutant quantities and hazards. And contaminated sites are only slowly being evaluated.

How do these sources compare in the Fraser Basin? In waste water volume (leaving aside questions of relative toxicity), runoff is approximately equal to all effluent point sources, and the latter are about equally divided between municipal sewage treatment and industrial discharges. No estimate is available for contaminated sites, but their volume will probably be much smaller even though surface runoff is sometimes involved as well as groundwater seepage.

FRAP's tasks have been to estimate the quantities and effects of such pollution in the Fraser River system and take steps to help reduce them.

CHRIS LAWS, MC

Contaminants washed from streets pollute watercourses.

SIGNS OF URBAN STRESS

CHANGES IN THE DELTA

Except in its upper reaches, the Fraser River is a silty brown colour. From aloft near Vancouver, the brown plume can be seen pushing out into and across the Strait of Georgia. The colour is not from pollution. It is the natural colour of the suspended sediment being carried by the water. Over many thousands of years, a portion of these sediments have been deposited where the river encounters tidal action, creating the Fraser delta. The continuing deposition of silt, especially in annual flooding, interacting with tidal currents, has given the estuary its shape.

The intertidal flats of Roberts and Sturgeon Banks show signs of sediment depletion

But this natural maintenance process is no longer occurring, FRAP studies show. Dikes, training walls, and dredging have channelled the arms of the Fraser and redirected flows and sediment transport. Only at tiny Canoe Passage, a channel too small to have been altered, can natural deltaic processes be seen. The intertidal flats of Roberts and Sturgeon Banks show signs of sediment depletion. Evidence of erosion in the vicinity of the Westshore terminal at Roberts Bank and the Tsawwassen ferry terminal warns of possible threats to those structures. The studies therefore signal the loss of delta habitat.

In the Fraser estuary, not all sediment transport goes downstream. Scientists have observed upstream movement of sediments in some channels carried by flooding tides. A net flow of sediment up the Pitt River has produced a reverse delta at the mouth of Pitt Lake. In some areas that have been

A jetty keeps tidal flats from being naturally replenished with sediment.

Greater Vancouver is gradually phasing out obsolete storm drain technology.

URBAN POLLUTION IN SILT AND FISH

Certain pollutants are signs of human activity:

- Fecal coliform bacteria levels in the estuary are very high in winter months. These have two origins, both urban: releases from the sewage treatment plants in the estuary during periods when chlorination is not used, and runoff from city streets and other locations where animal droppings are washed away.

- Polycyclic aromatic hydrocarbons (PAHs), produced by fossil fuel combustion, and polychlorinated biphenyls (PCBs), used in electrical equipment, have been found at elevated levels in sediment and fish in the Lower Fraser river and estuary and in the Kamloops area in the Thompson.

These findings show that urban pollution is finding its way into natural systems and, as populations grow, will do so increasingly unless something is done.

dredged (eg Queen's Reach near New Westminster and Main Arm by Steveston Cut and Steveston Jetty), some scientists suggest there are signs of an upriver return of sediment quantities removed by dredging. This would support the general observation that sediment configurations on river bottoms are developed into a state of equilibrium over time and tend to re-establish themselves when disturbed. Some observers argue that the use of sandy dredged sediment for construction may be effectively starving the delta of sand.

EFFECTS IN ESTUARY FISH

Scientific data indicate that in fish tissue concentrations of a number of contaminants of historic concern, reductions have occurred where action has been taken. These include certain organochlorines (PCBs, chlorophenols, pesticides, dioxins, and furans) and at least

EC AQUATICS SECTION

Measuring the health of the river

two metals (lead and arsenic). Yet developing pharmacological and ecological understanding continually raises new concerns about chemicals whose effects, individually or in combination, have not been well studied. The past gives no reason to be complacent about the future.

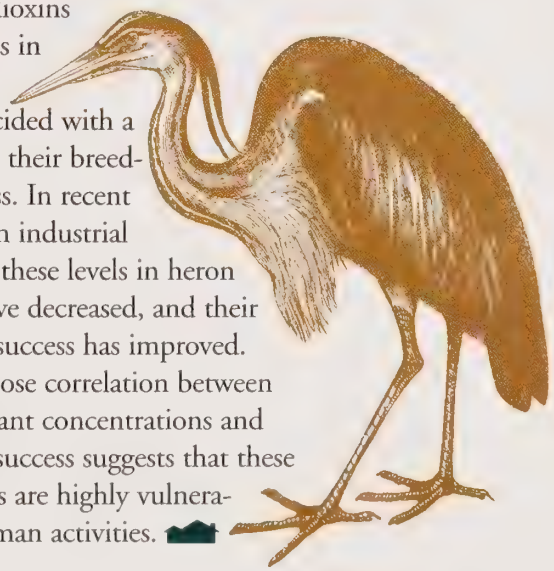
Scientists are not yet sure of all the pollutants involved and where they may come from

For example, fish in the Fraser estuary are reacting to contamination. Samples of two resident fish species, peamouth chub and starry flounder, showed mixed function oxidase (MFO) activity in their livers. MFOs are enzymes produced by the liver to eliminate some toxic organic chemicals. They therefore reveal the fish's exposure to those chemicals, unlike other health indicators, which usually reflect the cumulative effects of all stressors, not just certain contaminants. Scientists are not yet sure of all the pollutants involved and where they may come from (though vehicle emissions are among the suspects), but the results indicate that MFO induction can serve as a first warning of contaminant exposure in the environment.

stressors

HERON BREEDING

The Great Blue Heron, which often symbolizes a tranquil and healthy environment, is under increasing stress around urban areas. Its nesting areas are being consumed by urban sprawl and are more and more disturbed by human activities. Industrial, agricultural, and residential contaminants are found in heron eggs. In the 1980s, scientists found that high levels of dioxins and furans in heron tissues coincided with a decline in their breeding success. In recent years, with industrial cleanups, these levels in heron tissues have decreased, and their breeding success has improved. But the close correlation between contaminant concentrations and breeding success suggests that these great birds are highly vulnerable to human activities.



Richmond 1930

Richmond 1995

EC AQUATICS SECTION

RISING IMPORTANCE OF URBAN RUNOFF

In total volume, urban runoff amounts to as much as all other effluent point sources combined, that is, municipal sewage treatment plants and industrial outfalls together. In harmfulness, urban runoff has in the past been less important, but that is changing. There are two reasons for this:

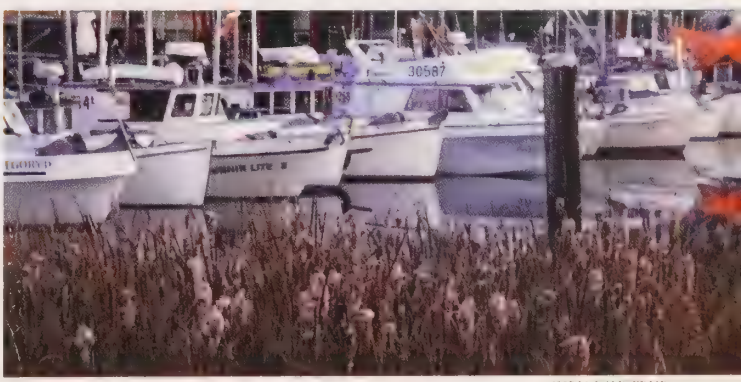
- The point sources have radically improved the quality of their effluent. The forest products industry has been making great strides in pollutant reduction, and the sewage treatment plants in the Lower Fraser are completing some significant upgrades.

Research is tending to attribute pollution increasingly to runoff sources

- Urban growth, and especially the increase in motor vehicle traffic, tends to increase the amount of urban runoff and the variety of contaminants it contains.

These changes can be seen in two traditional general indicators for comparing pollution levels. Biochemical Oxygen Demand (BOD) indicates the amount of organic material in the water, the decomposition of which depletes oxygen levels and may leave the water uninhabitable by fish and bottom-dwelling organisms. Total Suspended Solids (TSS) indicates the amount of particulate material being carried in the water, and pollutants often stick to, or themselves are, small particles.

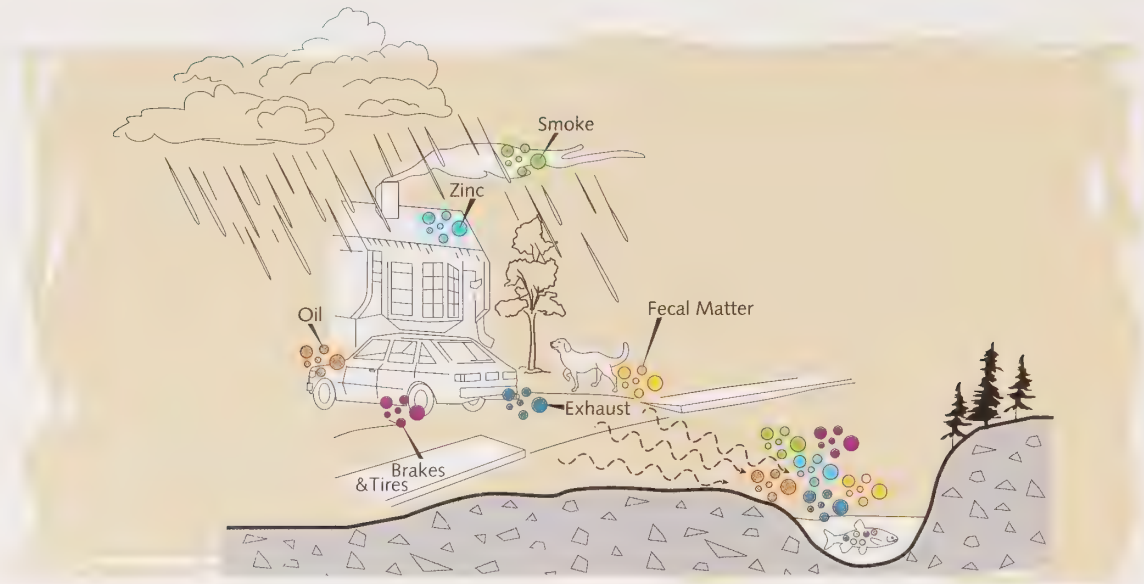
These measures can give an idea of the relative polluting effect of industrial discharges, municipal sewage treatment plants, and urban runoff. In the Upper Fraser (above Prince George) and the Middle Fraser (Prince George to Hope), industrial discharges are much more important than runoff or municipal sewage as a source of BOD and TSS. However, in the Lower Fraser (below Hope), the situation is very



CHRIS LAUSTRUP

Left–The changing face of the Fraser Estuary in the 20th century

NATIONAL AIR PHOTO LIBRARY A2238 - 36 (1930); TRIATHLON MAPPING CORPORATION (1995)



different. Once the Vancouver sewage treatment plant upgrades are completed in 1998, urban runoff will be the predominant source both of BOD and (by far) of TSS. Moreover, the overall trend for urban runoff is upwards, while those for industry and municipal sewage are downwards.

Indeed, research is tending to attribute pollution increasingly to runoff sources. When elevated pollutant concentrations were found in the Thompson River near Kamloops and in Kamloops Lake, early suspicions implicated the Weyerhauser Pulp and Paper Mill. However, further research with improved methods showed that the mill was in compliance with regulations on all contaminants. The culprits turned out to be a number of storm sewer outlets into the Thompson River. The highest oil and heavy metal contamination was found in a storm sewer draining a residential area and another draining a highly industrialized area. Increasingly, reducing pollution is the responsibility of everybody in the community.

THE BRUNETTE WATERSHED: A CASE STUDY

The effects of urban runoff can be seen in the Brunette watershed, a chain of small lakes and streams within the developed core of Greater Vancouver. The area is highly prized for outdoor recreation and as a green refuge for people and wildlife. The Brunette River, which flows through Burnaby and

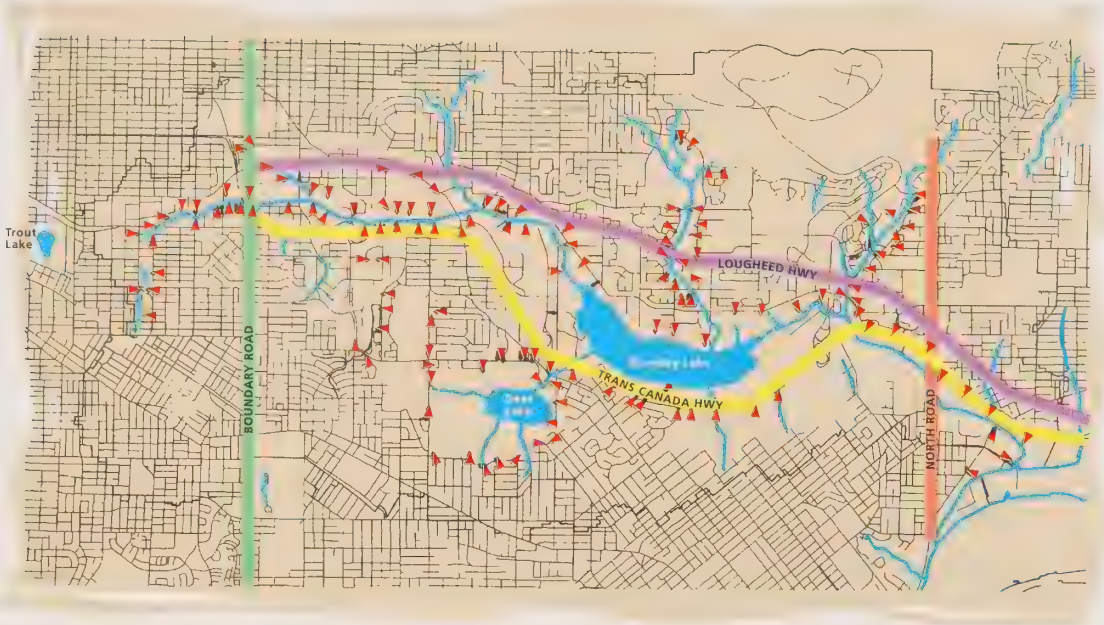
forms the border between New Westminster and Coquitlam, is a small tributary in the Lower Fraser Valley. In such streams, two-thirds of Fraser River coho try to spawn. The watershed is also divided by the Trans-Canada Highway and surrounded by residential, commercial, and industrial sites. The Brunette watershed therefore presents a classic instance of vulnerability to urban development and pollution. Besides the encroachment on wildlife habitat, the watershed has a variety of pollution sources: atmospheric deposition, storm water runoff, spills and dumping, sanitary sewers connected illegally, and fecal matter from pets and urban wildlife. Pollutants from all these sources are channelled by runoff into the Brunette ecosystem.

Pollutants are channelled by runoff into the Brunette ecosystem

With urban development, more than one-quarter of the surface area of the watershed is now impermeable to water. Rain falling on these surfaces gathers airborne pollutants from exhausts, chimneys, and industrial activity, as well as oils, chemicals, and other substances on the ground and carries them through dozens of storm drains into the lakes and streams of the watershed. The long history of development in the Brunette watershed, from forestry, to agriculture, to residential, commercial, and industrial, has had a series of effects on its waters which have been recorded in the sediments of Burnaby Lake.

FRAP studies show the lakes and streams of the Brunette watershed have an abundance of the contaminants typical of runoff: fecal coliforms, high concentrations of metals (copper, zinc, lead, and manganese), PAHs, and hydrocarbons (oil derivatives), and low oxygen. Furthermore, these levels rise sharply during and after rainfall. During storms, measurements show very high levels of dioxins, furans, PAHs, and metals both in water and in sediment suspended in the water. The rain itself often contains concentrations of many of these contaminants, having caught them in its descent and deposited them in or near the surface water.

As sediment is deposited on lake bottoms, the resulting layers provide a permanent record of runoff contamination at successive periods. Scientists take vertical core samples of the sediment to study these layers. FRAP studies of sediment cores from Burnaby Lake show how contaminants have changed. For example, lead concentrations reached a peak in 1973 and have declined since then, in part because of the gradual adoption



Storm sewers have made the Brunette system a sink for pollutants.

of unleaded gasoline. The cores also show the signature of a local metal plating facility with increases in copper, zinc, lead, and mercury in the early 1970s, followed by some declines. PCB and DDT concentrations have declined since the 1950s and 1960s.

What would these concentrations have meant for Brunette's water creatures? Some glimpses may be available from a FRAP experiment using the mesocosm device for observing and measuring the reactions of organisms to water pollution. Tests were conducted of metals at guideline concentrations (which are often much lower than those in the Brunette system). Some macroinvertebrate species (such as mayfly larvae) were more affected than others (such as caddisfly larvae). Scientists then sampled the same species in the Brunette system. They found that, indeed, there was a shortage of the more sensitive species, compared to the less sensitive species.

WAYNE BELZER

Burnaby Lake

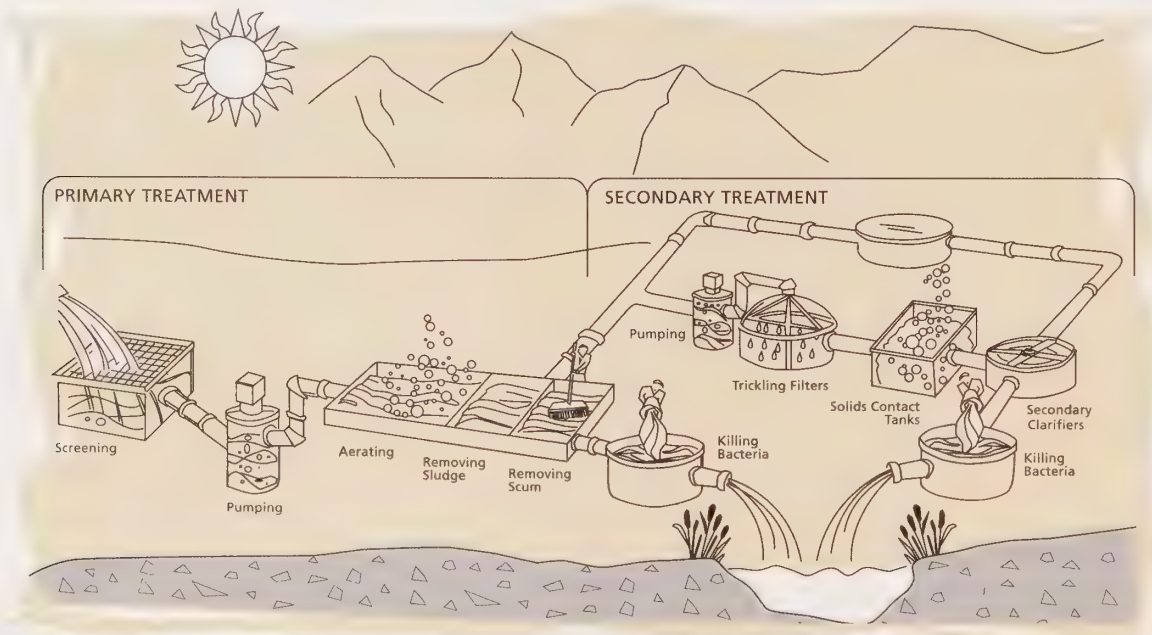
Left–The tranquillity of the Brunette River belies the contamination below the surface.

The recovering tidal flats at Iona Island

SEWAGE TREATMENT

There are 90 municipal sewage treatment plants in the Fraser Basin. Of these, 87 are upstream of Surrey and account for only 13 per cent of the total volume of sewage discharged into the Fraser system. The three massive plants in the Fraser estuary – Annacis Island, Lulu Island, and Iona Island – account for nearly nine-tenths of the total volume.

In the 1980s, the three big plants in the estuary often did not have the treatment capability to meet their effluent quality permit levels and in one case had a poorly located discharge outfall. The effects were visible in the estuary. All life was eliminated in the vicinity of the Iona Island discharge point. The estuary was very vulnerable. The mixing of salt and fresh water makes it a highly productive habitat for birds and marine life. With water moving more slowly through the estuary than the main channel upstream, the backwaters of the estuary were prime habitat for fish. Because of tidal currents, pollution would frequently back up the arms of the Fraser as far as New Westminster. Long before FRAP, the insufficiency of these facilities was well known, and contaminant reduction targets had been established for sewage and for combined sewer overflows (CSOs) But there were many delays.



Primary and secondary sewage treatment

ADAPTED FROM G.V.R.D

Improved sewage treatment

Environment Canada was among the many advocates of treatment plant upgrades, which finally got under way when the various levels of government came to agreement on responsibilities and funding. The upgrades involve full secondary treatment at Annacis and Lulu (and at the Lansdowne plant in Prince George).

sometimes unable to meet the old standards for BOD (130 parts per million at Annacis and 169 at Lulu) and for TSS (100 ppm at Annacis and 128 at Lulu), are now designed to achieve output concentrations of 15 ppm for each. The Annacis and Lulu upgrades are also expected to reduce their output of metals and organic pollutants by 54 per cent and 66 per cent, respectively.

The Iona extension allowed the re-establishment of benthic communities on Sturgeon Bank

Projects cosponsored by FRAP included development of new technologies, design guidelines, and education programs for sewage treatment and disposal. For example, a study was carried out at Prince George to determine the source of toxic discharges to the sewer system resulting in treatment plant upsets and to find ways to reduce the frequency and duration of the upsets. A study at the District of Hope identified measures to get the most out of the current treatment plant and recommended upgrades. A design manual was also developed for technologies especially effective in cold and temperate climates.

The results are dramatic. Total Fraser Basin municipal sewage output will be reduced by 84 per cent for BOD and by 68 per cent for TSS. The upgraded plants, which were

CHRIS LAUSTRUP

Iona outfall extension

The 1988 extension of the Iona outfall diffuser beyond the estuary into the Strait of Georgia eliminated the old discharge point on Sturgeon Bank. This allowed scientists, with FRAP's help, to study the re-establishment of benthic communities on the bank. They demonstrated many positive trends. Levels of all metals have decreased or stabilized. Concentrations of copper, mercury, and zinc in the Macoma clam have declined,

LAUREN ROSS

Collecting samples on the mud flats

as have those of copper, mercury, lead, silver, and cadmium in sediments. Oxygen in the water above the sediments has recovered from the low levels experienced when the outflow was on the bank. Yet nitrate and ammonia are still being released vigorously from the intertidal sediments, as a result of the high organic carbon levels still present there.

The vicinity of the former discharge is no longer barren of life. Macoma clam densities are now similar to those in other estuaries, while the amphipod, Corophium, has recovered to normal levels. The formerly dominant blue-green and green algae indicative of pollution have given way to diatoms, as in other areas of the banks. More improvement can be expected when combined sewer overflows have been eliminated at the plant.

Water conservation

As populations grow, so do the benefits of conserving water. Using less water in urban areas reduces the cost of increasing sewer system capacity and lowers the risk of combined sewer overflow.

However, with water, as with energy or raw materials, conservation initiatives often encounter inertia or even resistance. Though the predicted benefits may be substantial overall, they tend to be widely distributed and gradually accumulated. The costs, on the other hand, tend to be concentrated and up front. For example, local politicians may object to the initial cost of installing water meters and discount the longer-term benefits of reduced supply costs and delayed capital expenditures on facility expansions. Like prevention, conservation requires thoughtful planning.

A number of water conservation programs aimed at municipalities, industries, institutions, and households had been proposed before FRAP but few had funding to proceed. They included economic instruments, pilot projects, and public and technical information programs. By providing funds for these activities, FRAP built partnerships, encouraged water conservation, and supported municipal planning in the province.

Using less water in urban areas reduces the cost of increasing sewer system capacity

FRAP helped Simon Fraser University sponsor a demonstration project on water conservation. The project converted boiler room air compressors from water cooling to air cooling. The conversion saved 60,000 cubic metres of water a year, for an annual cost savings to the university of $29,000. At this rate, the project would pay for itself in only three years. The university is now looking for other conservation activities on campus. However, the university faces a barrier in making even highly remunerative investments: its capital budget is separate from its operating budget with no mechanism to pay back capital investments from operating cost savings beyond a single fiscal year. Nevertheless, Simon Fraser University physical plant staff presented details of the pilot project at several GVRD workshops. The university has since been able to undertake at least one water conservation project a year of similar scale and payback period.

FRAP then worked with GVRD on analyses of potential savings from water conservation in several industries and on methods of carrying out water audits at selected establishments to demonstrate possible savings. These analyses were used at later GVRD workshops with industries on water conservation.

Simon Fraser University is demonstrating water-saving technology.

FRAP also helped sponsor an economic analysis of universal water metering in the GVRD. The unanswered question was whether installation costs would outweigh long-term costs for expanding water facilities. The study, published by GVRD, argued that, while indoor metering would be advantageous, outdoor metering would not be, because outdoor meters would cost so much more to install.

NON-POINT SOURCES

As industrial and municipal point sources of emissions and effluents become better identified, regulated, and controlled, the vast array of non-point sources moves to the forefront as a critical problem. We have seen this shift in the increasing importance of urban runoff in polluting the watercourses of the Fraser Basin.

Paved streets collect contaminants.

An aspect of the emerging importance of non-point sources of pollutants is the need for a much wider public involvement. Point sources have managers, with whom authorities can work on technical issues of pollution abatement. But non-point sources involve everyone – small firms, individuals, groups, and institutions – and the many different ways each contributes to pollution. Responses to non-point source pollution will thus require changes in public attitudes and practices and therefore programs of public information and education.

But more than public participation will be required to reduce non-point pollution. A great deal of it occurs because of the physical structure of cities. Urban sprawl, with its reliance on vehicle travel, and therefore on paved corridors, streets, and lots, imposes a degree of non-point pollution no matter what individuals try to do. In this sense, pollution reduction (like energy efficiency and waste materials reduction) will depend in part on planning to reduce urban sprawl and encourage more compact cityscapes, as well as on transportation alternatives to single-occupant vehicles.

Another example is industrial technology and practices. Every sector, from service stations to small manufacturing to materials handling to fish processing, uses equipment and processes that create pollution and environmental stress. Though their individual effects may be minor; their combined effects are significant. Improving management strategies and encouraging employee awareness and stewardship will be crucially important.

ZAHEER MANKI

Some management failures are obvious.

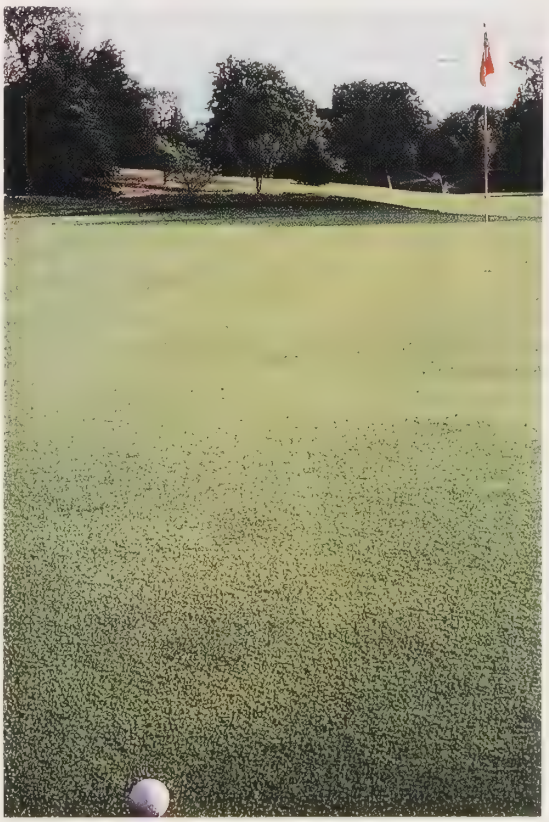
Best management practices

FRAP has sponsored the development of guideline documents on improving environmental performance in 15 industrial sectors, the development of pollution prevention plans at two industrial facilities, and the demonstration of two new industrial processes.

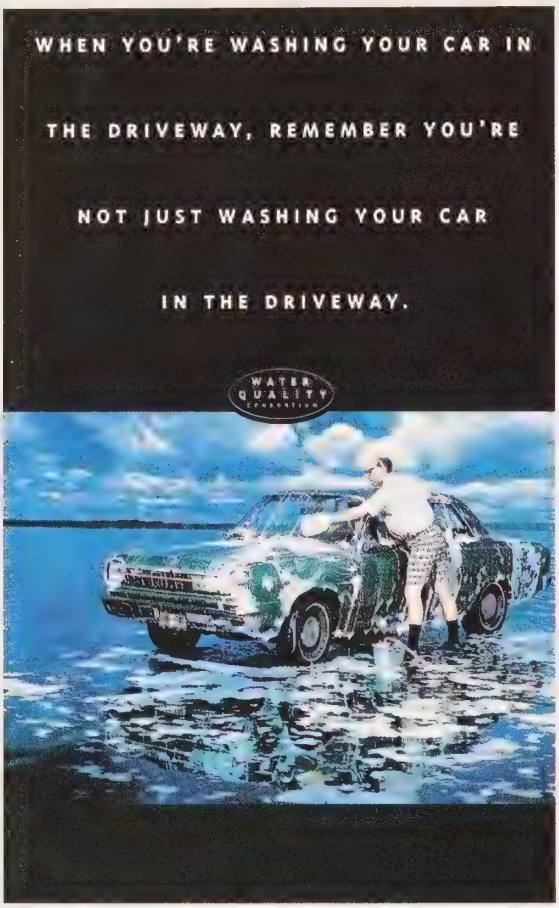
In some cases, the potential for improvement is surprising. For example, British Columbia has 17 dry bulk loading facilities which handle grain, metal ores, coal, and chemicals such as dry sulphur. Of these, 12 are located in the Lower Fraser Basin and Burrard Inlet. When FRAP staff began inspecting compliance with guidelines for grain handling in 1995, the result was a remarkable reduction in BOD discharges by 95 per cent and TSS discharges by 89 per cent. This was due mainly to improvements in the cleaning up of spilled grain.

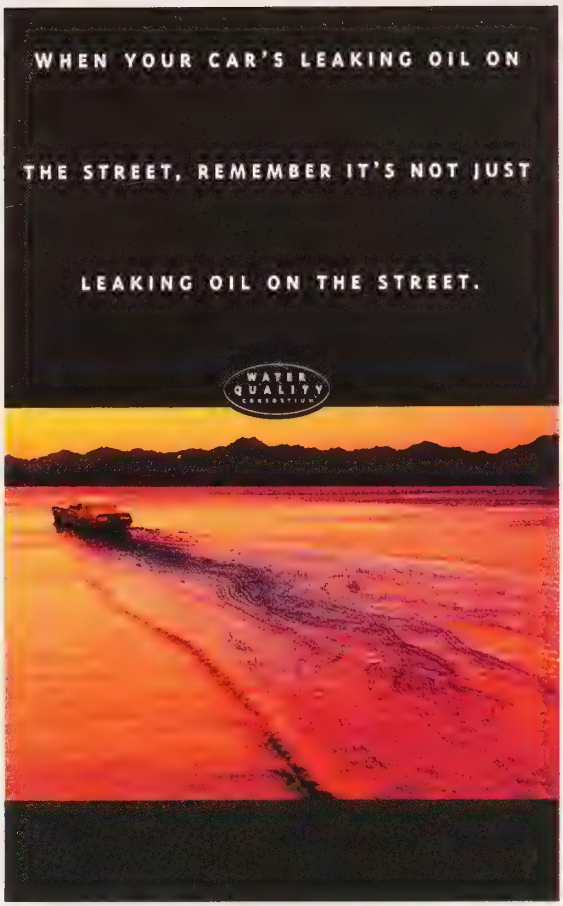
Another example is fish processing. In 1996 FRAP inspectors tested effluents from fish processing facilities in the Fraser Basin that discharge directly into fish-bearing waters. Three effluent streams were found to be out of compliance with the Fisheries Act and to have BOD or TSS levels harmful to fish. The changes recommended in the FRAP-sponsored Guide for Best Management Practices for Fish Processing Plants have been shown by experience elsewhere to cut fish processing organic pollution by up to half. By 1996, 47 per cent of fish processing facilities in the Fraser Basin had implemented these practices. This inspection program will continue, with a target of achieving more than 90 per cent implementation.

A third example is FRAP's guide to best management practices on golf courses: Greening Your BC Golf Course. This booklet, aimed at golf course designers, managers, and employees, gives advice on managing stormwater and irrigation, dealing with pests, and running the maintenance area.



Any business can improve its environmental performance.





Environmental management is shown to have implications for every aspect of golf course operation and to be an indispensable part of competent overall management.

Public education

In cooperation with partners, FRAP coordinated a public awareness campaign on non-point sources of pollution in the Fraser Basin. The campaign focused on lawn care practices, car maintenance, and alternative household products. Posters were distributed, television advertising was undertaken, and fact sheets were distributed at conferences and shows. FRAP also cosponsored a circular, Current Trends, which focused in part on urban and agricultural runoff in the Lower Fraser Valley, its effects, and how it can be reduced.

FRAP funds and reviews contributed to an overview report, Multiple Account Analysis for Non-Point Source Pollution in B.C. This document estimates the economic losses and the social and environmental harm caused by non-point source pollution across the province. The report shows them to be

considerable and provides strong support for an action plan.

FRAP has worked closely with BC Environment in designing, reviewing, and supporting development of a Non-Point Source Action Plan.

User-pay for garbage disposal

The provincial objective to reduce by half the quantity of waste going to landfills has challenged many municipalities inside and outside the Fraser Basin. As valuable as the Blue Box system has been for awareness, participation, and effectiveness, it is limited in its ability to divert waste from landfills.

One strategy is a user-pay system for garbage collection, with bag limits and over-limit pricing. Such a system is already operating successfully in parts of Victoria and Vancouver. FRAP, in partnership with BC Environment and various local governments, sponsored workshops in the Lower Mainland, Kamloops, and Prince George. The workshops outlined key issues and methods, and were well attended by local government staff. By December 1997, out of 43 communities surveyed, 34 had already implemented, or were about to implement, such systems.

RICHARD GLUE

CONTAMINATED SITES

Contaminants are still present in, and leaching from, many old sites, since abandoned, where traditional material handling and waste management practices were environmentally unsound.

As of December 1997, half the contaminated sites registered in SITE, the provincial database supported by FRAP, were in the Fraser Basin. Of these 1627 sites, 68 per cent were in the Lower Mainland, 10 per cent around Kamloops (Thompson), 5 per cent around Williams Lake (Middle Fraser), and 17 per cent around Prince George (Upper Fraser).

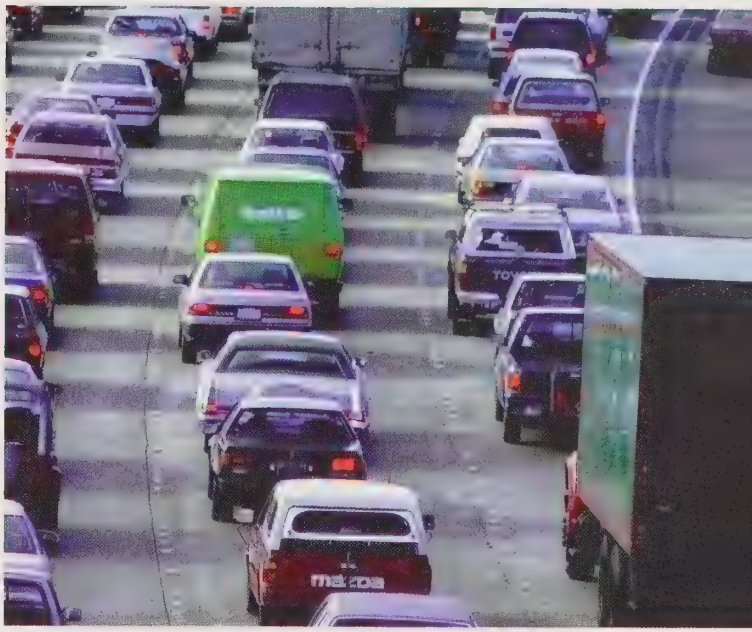
At the beginning of FRAP, Environment Canada was negotiating the assessment and clean-up of approximately 35 sites in the Basin. As of December 1997, the department was involved actively with 140 sites on federal land, of which 15 were cleaned up during FRAP's mandate.

Although better industrial practices have reduced the number of abandoned sites requiring clean-up, more old sites are being discovered all the time, particularly in the Lower Fraser.

RICHARD GLUE

Oozing tar at an abandoned industrial site before clean-up

AIR QUALITY



BENEFIT-COST ANALYSES

Air quality in the Lower Mainland is a long-standing and growing environmental issue. A variety of pollutants, especially from vehicle emissions, pose a threat to human health and to plants and animals. When combined with meteorological conditions that often occur in the areas of the Lower Fraser Valley where mountains trap the air, certain emitted chemicals produce an unsightly layer of photochemical smog. To deal with deteriorating air quality, the Greater Vancouver Regional District has implemented and strengthened an air management plan, with associated research, monitoring and control activities. Some of the measures contemplated or implemented impose significant costs on owners of factories and vehicles and are the subject of continuing political debate and public consultation. Whether the results of proposed changes will be worth their cost is a question that continually arises in public policy development.

In cooperation with the provincial government and the GVRD, FRAP developed the terms of reference for a full benefit-cost analysis of the air management plan. The extensive study, conducted by a consortium of consulting firms, concluded that, over 25 years, the plan would save at least $2.8 billion more than it would cost. Most of the benefits would consist of reduced risk of human death and reduced medical costs. Other benefits would include improvements in crop yields and visibility. After completion of this study, the provincial government continued to refine the methodology, applied it to other parts of the province, and produced an updated analysis which concluded that the benefits would be even greater than originally estimated.

A variety of pollutants, especially from vehicle emissions, pose a threat to human health

EC AIR QUALITY SECTION

Fraser Valley mountains trap polluted air.

The study, and its approach, attracted a great deal of interest from industry and government. Both GVRD and provincial politicians used the findings to urge stronger air quality controls. The data were used by planners and in public information and educational pamphlets. Public agencies and industry associations scrutinized the study method, and the Canadian Petroleum Producers Institute sponsored some critical examinations of the approach. As the first study that justifies air quality control on economic grounds, it could set a precedent for similar studies elsewhere in Canada.

The relationship between fine particulates in the air and human death has drawn much attention

The study method uses epidemiological evidence to predict human health effects from airborne pollutants. The Canadian Council of Ministers of the Environment is now using a similar method to review the benefits of reformulating fuels to make them cleaner, such as by reducing sulphur content. The relationship highlighted by the study between fine particulates in the air and human death has drawn much attention. The GVRD is now reviewing particulate standards in the Lower Mainland, and national agencies are developing a national standard for particulate concentrations in ambient air.

Left–Measuring air quality at Burnaby Lake

garbage disposal fee

Environment Canada and its partners in the air quality study formed a standing committee to address air quality issues from an economic standpoint. This committee sponsored further studies and contributed substantially to the province's new pilot program on greenhouse gas emission trading. FRAP also helped support the development and 1997 launch of the pilot greenhouse gas emission trading program.

effluent charges

ECONOMIC INSTRUMENTS OF POLICY

water metering

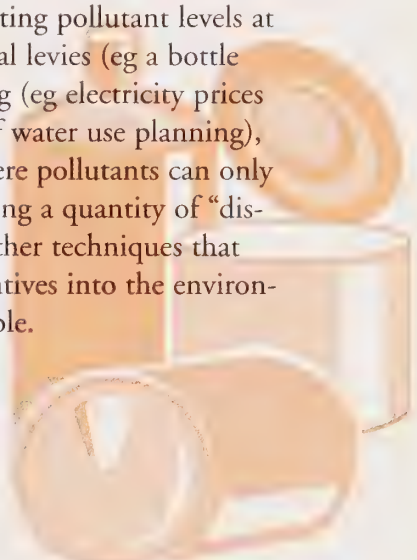
Environmental policy has traditionally relied heavily on regulation as an instrument of change. Regulation specifies what is permissible or prohibited. This might be a concentration level of a pollutant, such as in effluent or vehicle exhaust, or a technology, such as secondary treatment of sewage. An abatement authority works with industry to help it meet the regulated standards, and an enforcement authority monitors and penalizes.

emission trading

A different approach to implementing environmental policy uses what are known as "economic instruments." With these, the goal is not to restrict choice but rather to steer it in desirable directions by changing prices to create incentives and disincentives. People (and communities and industries) often make poor environmental choices when prices do not reflect the real environmental costs involved. By altering prices to make them better reflect the relative environmental costs of the alternatives, people can be encouraged to make better environmental choices.

People often make poor environmental choices when prices do not reflect the real environmental costs

Economic instruments of this kind include user charges (eg a fee for garbage disposal), effluent charges reflecting pollutant levels at outfalls, environmental levies (eg a bottle deposit), social costing (eg electricity prices that cover the costs of water use planning), emission trading (where pollutants can only be discharged by buying a quantity of "discharge space"), and other techniques that insert economic incentives into the environmental choices available.



BOB TORTORELLI

A thermal power station

Emission trading in air pollutants

The GVRD had earlier explored the concept of emission trading for selected air pollutants being discharged by industrial point sources: nitrogen oxides (NOX) and volatile organic compounds (VOCs). But the idea had languished because of insufficient public and political awareness and interest. FRAP, in partnership with BC Environment and the Society for the Prevention of Environmental Contamination, presented a stakeholder workshop on the issue. The partners then sponsored a study which concluded that an emission trading program for NOX, VOCs, and fine particulates would be feasible and cost-effective for the region. However, broad support for the concept was still lacking.

FRAP and partners then commissioned further investigation of the kinds of research, consultation, and decisions that would be required to develop a full emission trading system. The GVRD continues to explore the possibility of using emission trading as one of its air management strategies.

Emission trading among firms discharging pollutants can take several forms. The central idea is that firms that reduce their contaminant emissions substantially beyond what is required of them are allowed to sell these "surplus reductions" to other firms who can use them as credits instead of making their own reductions. In effect, the purchasing firm pays the selling firm to make the required reductions on its behalf. Businesses tend to prefer emission trading to traditional plant-by-plant emission regulation because it avoids "micromanagement" of their technology by outsiders and it allows the reductions to be made by those firms best able to afford them.

BOB TORTORELLI

A petroleum refinery

PROTECTING HABITAT

GRAHAM OSBORNE

FRAP and its partners purchased 441 hectares of wetland and associated upland property in five Lower Mainland locations. The total cost was $9.1 million, of which FRAP's share was $1.3 million.

The most secure way of protecting habitat is to buy it

PURCHASES

The most secure way of protecting habitat is to buy it. But land costs in the Fraser Valley are high, so purchases were originally expected to be limited to a few hectares at most. However, purchasing opportunities were opened by partnerships with other agencies. Environment Canada's partners in securing habitat included Transport Canada, BC Environment, The Nature Trust of BC, Ducks Unlimited Canada, Wildlife Habitat Canada, the Greater Vancouver Regional District, and various municipalities and organizations in the Lower Mainland. Purchases were made through the Lower Mainland Nature Legacy Program, and the Pacific Estuary Conservation Program.

IDENTIFICATION AND PROTECTION

FRAP participated in the Wetlands Working Group, whose members included Environment Canada's Canadian Wildlife Service, BC Environment, Ducks Unlimited Canada, Land For Nature, The Nature Trust of BC, and others. This Group undertook an inventory of wetlands in the Lower Mainland, identified priority sites, advised on habitat purchases, and provided guidance to planners on protecting wetlands on crown land.

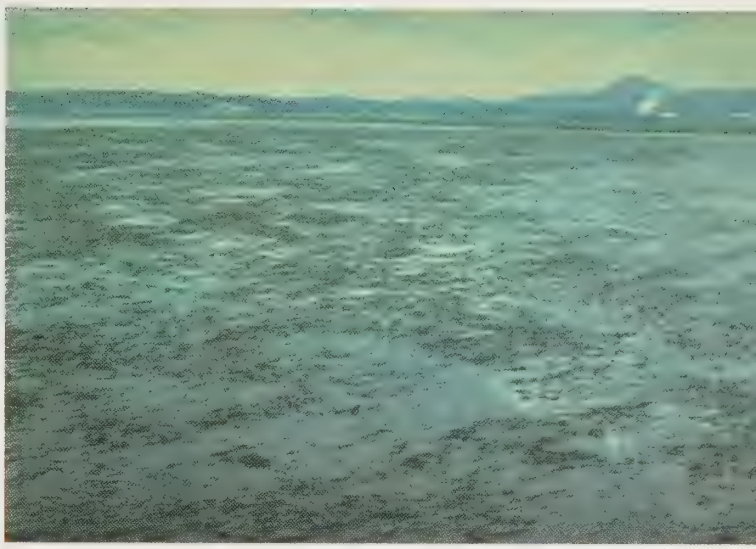
WOOD WASTE – A POTENTIAL RESOURCE?

Wood waste is becoming a substantial environmental problem in the Fraser Basin. It is being generated in growing amounts by urban expansion, with its land clearing, new construction, and demolition of old buildings. Most of this waste goes to landfills. Lumber processing, by contrast, produces less and less wood waste. What was once seen as waste is now used for pulp chips, cogeneration projects, livestock bedding, and remanufactured products, leaving only bark and very rough material as residues. Even so, provincial regulations phasing out beehive burners make it difficult for lumber companies to dispose of the waste they do produce. A portion of wood waste from many sources finds its way into watercourses, where its decomposition raises BOD levels and threatens habitat.

To help find reuse and recycling opportunities for this waste, FRAP conducted an inventory of wood waste streams in the Fraser Basin. In all, 4.3 million cubic metres of unused wood waste is generated in the Basin every year. About half comes from land clearing, and only one-fifth from lumber processing. Building construction and demolition account for most of the rest. A further FRAP study examined the feasibility of diverting land clearing waste from landfills to pulp mills. A pilot project is under way.

To date, more than 12,400 hectares of vulnerable wetland areas on crown land have been given a protected designation, including Boundary Bay (11,470 ha), South Arm Marshes (886 ha), and McIntyre Creek (87 ha).

More than 12,400 hectares of vulnerable wetland areas on crown land have been given a protected designation



MICHAEL DUNN

Unappreciated by most people, eelgrass is a staple for migratory birds.

The Wetlands Working Group also produced a report, Wetlands of the Fraser Lowland: Ownership, Management, and Protection Status, which, together with the inventory, is an essential resource for securing and managing wildlife habitat throughout the Lower Mainland.

An intertidal vegetation mapping project was conducted in the Boundary Bay, Semiahmoo Bay, and Roberts Bank areas, an important habitat for migratory birds. The distribution of plant species and their ground cover have been digitally mapped. The Vancouver Port Corporation has used these data in restoring the area between the Roberts Bank and BC Ferry causeways, and a number of private remote-sensing companies have used the mapped data to calibrate their image analysis.

COMMUNITY AWARENESS AND ACTION

FRAP and partners sponsored a number of programs and publications aimed at promoting habitat conservation by communities on private land. For example:

- Community Greenways – linking communities to country and people to nature. This program encourages local governments to designate "greenways," which are landscape corridors that link natural areas and provide wildlife habitat and recreational opportunities. The published guide explains the concept, offers practical advice on community planning approaches, and provides recommendations for implementation and management and for addressing land tenure and regulatory issues.

Greenways concepts are being integrated into community plans (Salmon Arm, GVRD), implemented as such (Prince

BOB SCHEER

Yellowthroat

Naturescape helps people improve habitat in their own backyards

George, Maple Ridge, Pitt Meadows), used in developing trail/bridge networks (Williams Lake), and used in environmental protection programs (North Vancouver). The approach is heightening public awareness, bringing together recreation, fish, wildlife, and greenspace interests, and fostering a stewardship ethic among urban residents and local governments.

• Naturescape – caring for wildlife habitat at home: This stewardship program helps people improve habitat in their own backyards. A series of region-specific publications explains types of habitats and how wildlife use native plants. Public demand for the booklets is very strong, and about 3000 participants in the Georgia Basin, including the Lower Fraser Valley, have each paid $20 to register with the program.

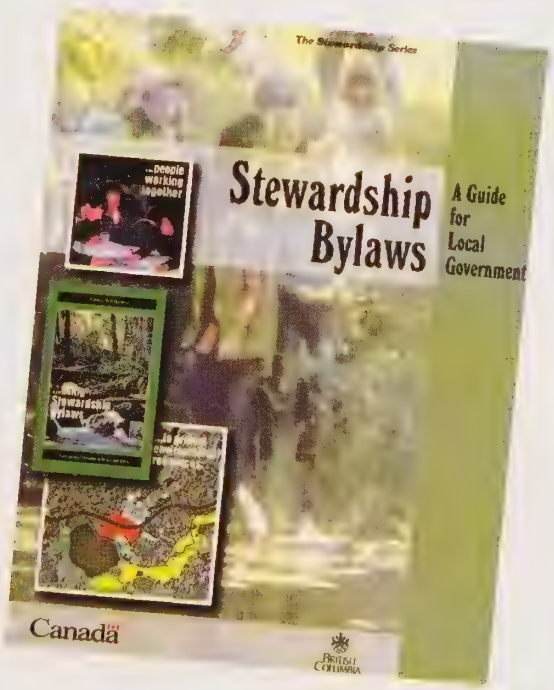
• Wetlandkeepers: This program, modelled on the successful Streamkeepers program developed by the Department of Fisheries and Oceans, is for people or groups interested in stewarding a wetland. Associated with an intensive two-day training course offered through Langara College, the Wetlandkeepers Handbook provides information on ecology and protection and gives practical step-by-step advice on wetland monitoring and stewardship. About 100 people have taken the course, and there have been requests for the handbook from individuals, landowners, community groups, and students from around the province. In addition, about 65 unemployed fishers have taken Wetlandkeepers training as part of a six-month retraining program offered in Surrey.

• Stewardship Bylaws – a guide for local government: This publication offers municipal planners model language for stewardship bylaws and practical advice for incorporating wildlife habitat stewardship concepts into local planning and decision-making.

These reports are available from Environment Canada.

EC AQUATICS SECTION

Children learn to care for the environment.



WHAT'S NEXT

THE NEW POLLUTION FOCUS: NON-POINT SOURCES AND URBAN RUNOFF

FRAP studies confirm that non-point sources and urban runoff are becoming the main pollution concern in the Fraser Basin. These are connected with urban sprawl and vehicle use and therefore with population growth, which is forecast to be dramatic in the next 25 years, especially in the Lower Mainland.

This will be a different and more difficult challenge than dealing with large fixed pollution sources like pulp mills and sewage treatment plants. Addressing non-point pollution sources means dealing with a vast number of small industries and with the general public. It means changing attitudes and behaviours, not just technologies and processes. How progress can be made in these directions has been demonstrated by many FRAP-sponsored programs. A continuing scientific inquiry into the many ecological connections to human and community well-being will play a vital role in persuading people to accept their responsibility to make changes in their use of vehicles, toxic chemicals, and fertilizers.

Although recent improvements to sewage treatment plants have reduced pollution from this source to the main river, population growth, particularly in the Lower Fraser Valley, will eventually overwhelm these improvements unless improved sewage treatment technologies are developed and implemented.

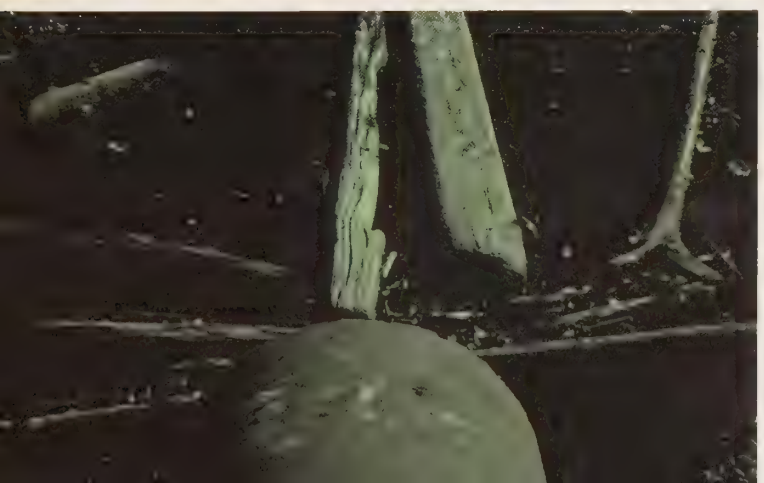
PROTECTING AND ENHANCING HABITAT

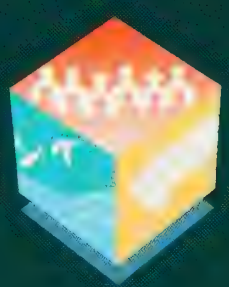
Good progress has been made in habitat conservation, thanks in part to FRAP's cosponsorship. But the challenge remains as important as ever:

- A large proportion of natural habitat has already been lost, especially in the Lower Fraser Basin, so that the surviving areas of habitat have become even more critical for wildlife and biodiversity.

- The pressures of urbanization and intensive agriculture on habitat will be increasing strongly in the next 25 years.

FRAP programs have shown that habitat conservation is popular with the public, can be linked with sustainable forms of urban design, such as Community Greenways, and can mobilize much volunteer labour. This good work must be continued by Basin residents and stakeholders, including Environment Canada.





Agriculture

FRASER RIVER ACTION PLAN

Canada

Additional copies of this report can be downloaded from the FRAP web site (http://www.pyr.ec.gc.ca/ec/frap/index.html) or by writing to:

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Contents

FRASER RIVER BASIN

Agriculture

Agriculture in the Fraser Basin is subject to competitive pressures that are just as varied and intense as those on other resource industries.

CHRIS LAUSTRUP

Dairy products, beef, pork, and poultry products, grains, fruits, and even market gardening produce are subject to intense international price competition. It is not easy to cover costs and get a return. Rising costs force farmers and ranchers to get the most out of their land, the value of which often soars near urban areas. Entrepreneurship and awareness of market opportunities are not lacking; in fact they sometimes create an over-investment that pulls prices quickly down. Moreover, new intensive methods of rearing livestock and growing crops may well create further environmental challenges.

Fraser River Action Plan (FRAP) staff developed a lot of respect for the environmental astuteness of the farmers and ranchers with whom they worked. Together they have identified harmful practices and developed more environment-friendly alternatives.

AGRICULTURE AND THE ENVIRONMENT

Agricultural activities can harm fish and wildlife in two basic ways:

- elimination of natural habitat: land use and watercourse alterations reduce and eliminate diverse, natural space, shelter, and food for fish and wildlife, generating ripple effects throughout the ecosystem.

- pollution: nutrients and pesticides volatilize into the air, seep into groundwater, and run off into streams, where they come in contact with fish and wildlife.

FRAP programs investigated issues and took action in both areas.

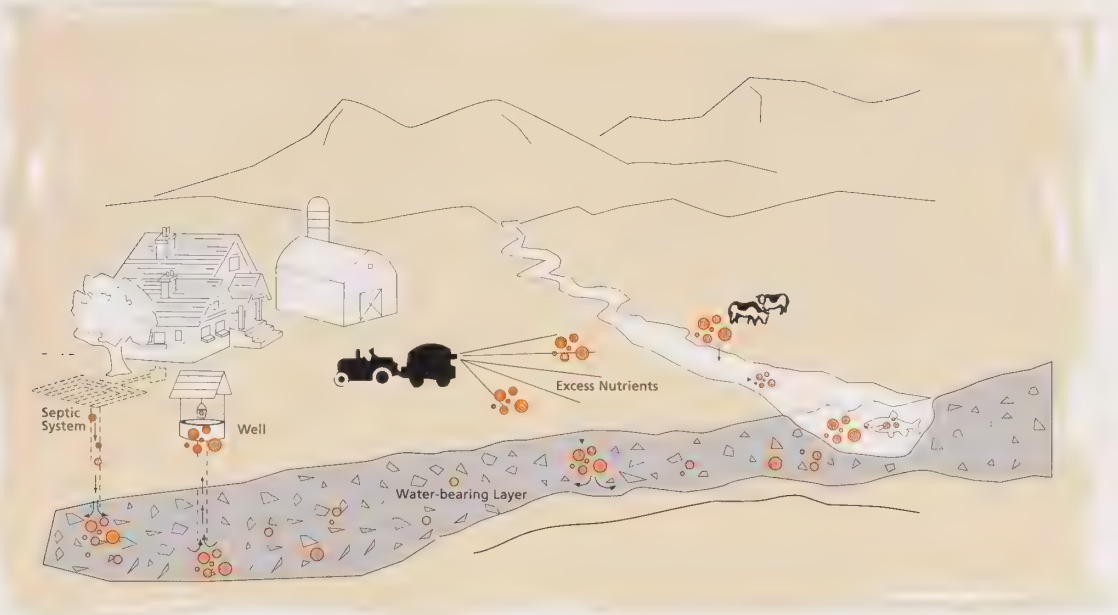
ELIMINATION OF NATURAL HABITAT

There are two forms of sensitive natural habitat which agriculture tends to threaten: wetlands and riparian (waterside) areas.

Wetlands, traditionally called (often dismissively) swamps, bogs, marshes, sloughs, etc, have been regarded in the past as waste land. In fact, wetlands shelter and nourish large numbers of birds and other wildlife. Often such land can be made agriculturally productive if it is drained. Thus the Sumas Prairie near Abbotsford, once a large lake surrounded by wetlands, was drained and diked in 1925 to control flooding and create fertile agricultural land. In this way, the expansion of agriculture and of urban areas in the Lower Fraser Valley has eliminated most of the original wetland habitat of pre-settlement times.

Riparian (waterside) vegetation provides food and shelter for many species.

Riparian habitats occur where land adjoins a water body, such as a lake, pond, stream, or river. On such banks the moist and fertile soil supports a lush and diverse vegetation of shrubs, deciduous trees, and grasses not found on drier uplands. Riparian habitat is indispensable to maintaining biodiversity (number and variety of organisms). Wildlife surveys show that riparian habitat in British Columbia provides food, cover, and nesting sites for the vast majority of all terrestrial vertebrate species. This rich vegetation is vulnerable to agricultural



Manure contaminants circulate through groundwater and surface water.

practices. Livestock in search of water may trample the bank and disturb the sediments. The farmer may reroute a stream to fill out a field or alter a drainage, run farm equipment across it, or cut down the trees and shrubbery lining it. Deprived of cool shade, the water will heat up to temperatures intolerable to fish and invertebrates. In such ways, waterside zones cease to be rich habitat.

POLLUTION

Agriculture introduces to surface water and groundwater (the water table) two main kinds of pollution: pesticides and nutrients. Although they might seem to have opposite effects – one killing and the other feeding – both can harm the natural environment.

Pesticides

Pesticides include insecticides, herbicides, and fungicides sprayed on crops to protect them from infestation. Such chemicals often persist,

Contaminants in surface water may be absorbed directly by fish and wildlife

so that the residues sprayed on the soil or washed by rain from the crops or adhering to the killed material linger on the ground. They persist especially in cool, wet soils, as are

FRASER BASIN COUNCIL

Better cattle management would have protected riparian vegetation and water quality.

found in the Lower Fraser Valley. When it rains, these poisonous residues are carried by runoff into the nearest surface water or seep down through the soil into the groundwater. Contaminants in groundwater may be drawn out by drinking water wells or may leak into surface water, adding to those flushed in by precipitation. Contaminants in surface water may be absorbed directly by fish and wildlife or cling to sediment and be taken up by benthic (bottom-dwelling) organisms which are then eaten by fish or wildlife. Once in the food chain, they may bioaccumulate in living tissue, which acts as a kind of filter or sponge collecting, concentrating, and holding them. Contaminant-laden animals may in turn be eaten by other animals, whose own bioaccumulation further concentrates the contaminants, and then the cycle may repeat. This reconcentration process up the steps of the food chain is called biomagnification.

Along the way, chemicals formulated to kill living matter remain active and destructive in the living tissue holding them, including human tissue. They follow metabolic pathways with destructive effects that the science of pharmacology is only beginning to understand.

Nutrients

Nutrients pollute in a different way. They are part of the agricultural cycle, being produced by livestock and poultry in manure and spread as fertilizer on cropland. The main nutrient culprits in the Fraser Basin are nitrogen (N), phosphorus (P), and potassium (K), substances familiar to gardeners from commercial fertilizer formulations. As nutrients, they nourish living processes and are taken up by the growing crops. The problem is that they are not entirely taken up, especially when overfertilization occurs, as it does in many parts of the Lower Fraser Valley. Nutrient residues remain in the soil and follow the same pathways to groundwater and surface water travelled by pesticide residues.

The main environmental damage is the suffocation of underwater life by eutrophication

At the concentrations normally encountered, nutrient contaminants are not as dangerous to living creatures as pesticide contaminants, though some other pollutants from manure such as those associated with fecal coliform bacteria can be harmful. The main environmental damage caused by nutrient residues is the suffocation of underwater life by eutrophication. It seems paradoxical that an overdevelopment of living matter (eutrophication) should in the end be lethal. What happens is an imbalance that removes oxygen from the water. An overstimulated growth of surface vegetation (eg pond scum) cuts off light, preventing underwater photosynthesis and oxygen production. It also creates large amounts of decomposing plant material which takes up any available oxygen in the water (increasing "biochemical oxygen demand," or BOD), leaving none to sustain animal life. A pond deprived of oxygen has a green surface but a brown interior. It has ceased to be habitat for anything except algae and bacteria.

FRASER BASIN ISSUES

FRAP studies and farm visits revealed two somewhat different sets of environmental problems associated with agricultural practices in different areas. In the Lower Fraser Valley (downstream from Hope), where the most intensive agriculture in the province occurs, the elimination of natural wildlife habitat by a combination of urban sprawl and agricultural development, is far advanced. With agricultural pollution, pesticide effects remain, though they are being reduced.

In the interior reaches of the Middle and Upper Fraser watersheds, the main agricultural effects on the natural environment involve habitat degradation from ranching. Destruction of riparian areas and wetlands for and by livestock is affecting water quality and eliminating natural habitat for fish and wildlife.

Destruction of riparian areas and wetlands for and by livestock is affecting water quality

Meanwhile, FRAP scientists found that nutrient overloads are occurring because of an oversupply of manure from livestock and poultry farming. Problems of manure storage and handling, as well as an overapplication of manure and fertilizer to crops, are causing pollution of ground and surface water and even of the air in agricultural areas of the Lower Mainland.

Left–Stream banks erode where riparian vegetation is missing.

FRASER BASIN COUNCIL

Where cattle have direct access to water, vegetation is trampled.

LOWER FRASER

HABITAT ENCROACHMENT: COMPETITION FOR LAND

The Fraser Delta is an important stopover for migrating birds on the Pacific Flyway. Some birds only pause to rest and feed, while others stay for the whole winter. Ducks, geese, swans, and others are attracted to the agricultural fields that have replaced their natural habitat. They are not always welcome. They feed on seeds and cash crops; their feet compact the soil surface, hampering drainage. Farmers often resent the flocks of birds they see picking over their fields and cutting into their productivity.

CANADIAN WILDLIFE SERVICE

Crops provide rich forage for migratory birds.

CANADIAN WILDLIFE SERVICE

A scientist studies a patch that was protected from foraging birds.

FRAP, in partnership with Ducks Unlimited Canada, local farmers and residents in Delta, and environmental organizations, sponsored the Greenfields Program, to promote the use of winter cover crops. These non-cash crops provide winter food for birds while reducing soil erosion, enhancing soil productivity, and diverting birds from cash crops. As a result, every winter since 1991 has seen more than a thousand hectares of Delta farmland planted in winter crops. The program is now delivered by a local community group, the Delta Farmland and Wildlife Trust. Communications and extension activities are part of the program, including a newsletter, promotional material, a video, and displays at local events.

The entire community has gained a better understanding of the value of farmland both for food production and for wildlife habitat, and a partnership has developed between farming and wildlife interests.

POLLUTION FROM PESTICIDES

Agricultural sources

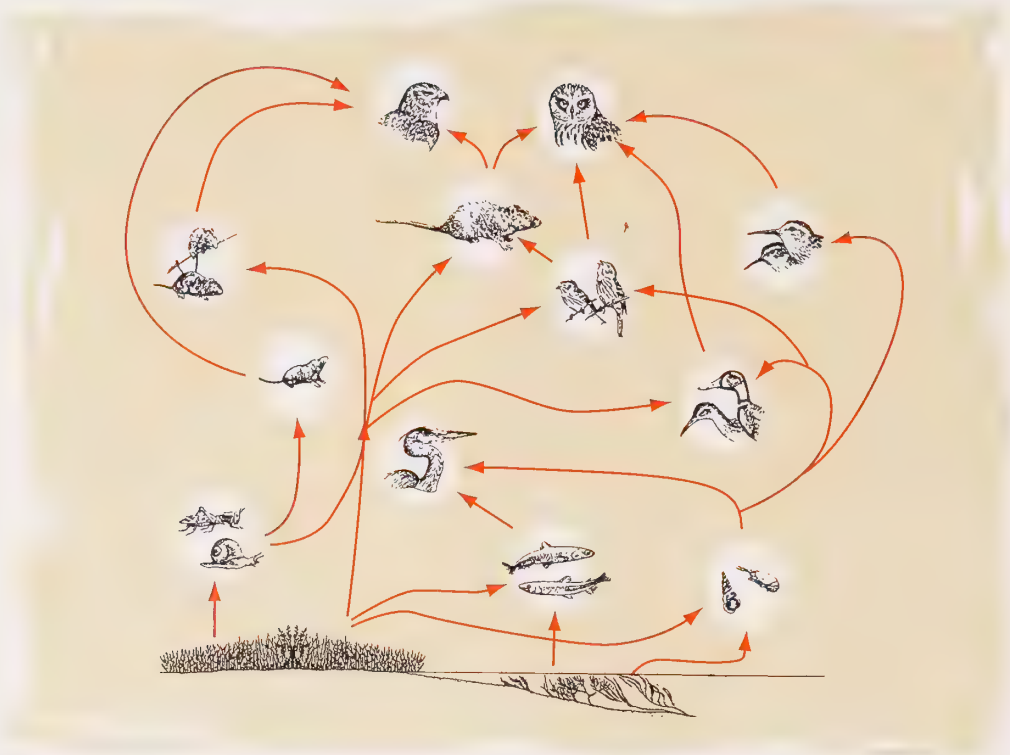
Since 1989, before FRAP, Environment Canada has been investigating pesticide poisoning of birds of prey in the Lower Fraser Valley. Scientists expected that pesticide concentrations would be highest in creatures high on the food chain, such as raptors, because of biomagnification. The studies showed that contaminant concentrations in these birds were highest in winter. In this season, scientists believe, waterfowl tend to feed in agricultural fields, ingest insecticides, fall sick or die, and are then eaten by birds of prey. The poisoning of raptors therefore indicates the prior poisoning of the birds and rodents they eat.

The Greenfields Program has seen more than a thousand hectares planted in winter cover crops

The studies showed that, from 1989 to 1997:

- at least 50 birds of prey were killed by pesticide poisoning, especially by granular insecticides, which persist in the sandy and wet local soils for many months.
- most were bald eagles, and a few were red-tailed hawks.

CANADIAN WILDLIFE SERVICE



The food chain causes contaminants to accumulate and concentrate in predators.

- seven insecticide chemicals were implicated: phorate, carbofuran, fensulfothion, dyfonate, fenthion, terbufos, and parathion.

As a result of the study, two of the chemicals (ie pesticide formulations containing them) were withdrawn from the local market: phorate and carbofuran. Fensulfothion is no longer manufactured. Dyfonate will be withdrawn from the local market after the 1998 growing season. The other three, fenthion, terbufos, and parathion, remain in use.

Environment Canada is collaborating with other agencies to find alternatives to these formulations to control, for example, wireworm infestations of potato crops.

As these chemicals are withdrawn from use, the incidence of pesticide poisoning has declined, suggesting an improving situation. In 1996–97, only one bald eagle in the Lower Fraser Valley was found whose death was attributed to pesticide poisoning.

Alternative sources

Current agricultural practices are not necessarily to blame for all pesticide levels in birds and fish in the Fraser Basin. In two species of fish selected by FRAP scientists as environmental indicators, mountain whitefish and peamouth chub, the pesticides measured in highest concentrations were DDE (a breakdown product of DDT) and toxaphene. The highest levels of DDE were measured in fish and suspended sediment from the

EC AQUATICS SECTION

Lower Fraser River. DDE was also the most prevalent pesticide derivative measured in the bird and mammal species sampled. DDT and its various breakdown products have been found in suspended and bottom sediments. However, both DDT and toxaphene have been prohibited in Canada for many years. The question is: where did these residues come from?

Residues of pesticides may linger in cropland soils, groundwater, sediments, and animal bodies

One possible source is past agricultural practice. Residues of pesticides and their breakdown products that are highly stable and bioaccumulative may linger in environmental storing places such as cropland soils, groundwater, sediments, and animal bodies. Another possible source is long-range atmospheric transport, possibly from countries in Asia where these pesticides are still in use. In support of this theory, the relatively undegraded state of some DDT samples suggests they have not been in the environment very long. Moreover, toxaphene residues have been found in Moose Lake, at the headwaters of the Fraser near Mount Robson, where the only likely pathway seems to be long-range atmospheric transport, deposition in snow and ice, and then release with meltwater. If the snowpack/glacial origin of these residues is confirmed, the implications are extensive: continuing low-level contamination of the Fraser Basin; potential for increased contamination levels if global warming increases melt rates.

Yet another possibility is suggested in an apparently anomalous finding of DDT in Nicola Lake, near Merritt, in circumstances suggesting a single recent release. When a pesticide is banned, some people may have quantities in storage. Eventually they may resort to illegal use or dumping to get rid of their supply.

In general, the lesson seems to be that a chemical may continue to contaminate the environment long after its use has been banned.

Birds of prey are at the top of the food chain.

POLLUTION FROM NUTRIENTS

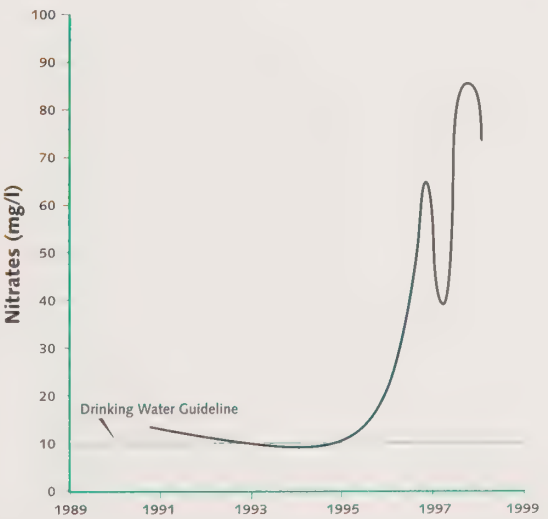
From a variety of evidence, including that of FRAP's own inspectors, FRAP scientists became aware of a "manure problem" in Lower Fraser agriculture. Surface water and groundwater are exhibiting signs of nutrient overload. The local oversupply of manure produced by intensive poultry and livestock farming is leading to handling and storage problems and to overapplication on crops. In a series of studies, FRAP has investigated the connections, the implications, and possible solutions.

Surface water and groundwater are exhibiting signs of nutrient overload

Signs of nutrient overload

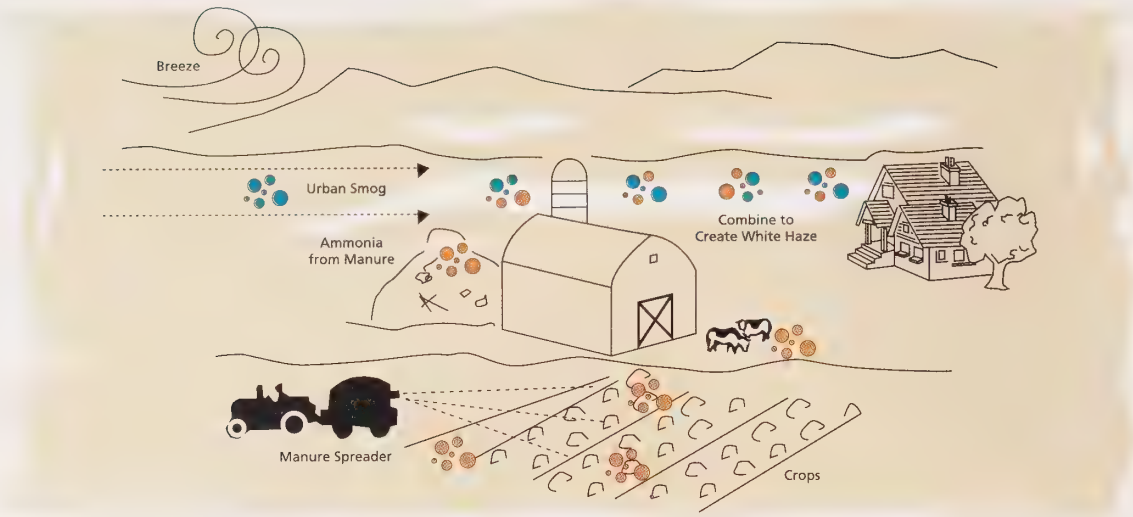
Several reports by FRAP and others confirmed that nitrate (a form of nitrogen) was present in the large groundwater reservoir called the Abbotsford aquifer, which extends west to Langley and south into Washington State. A 1993 survey showed that more than half of the 117 domestic, municipal, and monitoring water wells on this aquifer had nitrate concentrations above the Guidelines for Canadian Drinking Water Quality limit of 10mg/L. Project Enviro-health's 1995–6 Final Report to the provincial Ministry of Health stated that a series of studies of the Abbotsford aquifer "have shown that nitrate contamination is a major concern to human health." In late 1997 the City of Sumas in Washington State, which derives drinking water from the Abbotsford aquifer, requested information from Environment Canada on contaminant levels in the aquifer as part of their development of a wellhead protection plan.

FRAP looked into the sources of the aquifer contamination. One study analysed nitrogen and oxygen isotopes in the aquifer and indicated that the nitrate was "predominantly derived from poultry manure and to a lesser extent ammonium-based fertilizers." Further studies comparing local septic systems with poultry manure handling confirmed that the latter was the main source.



Left–Irrigating crops at Judson Lake over the Abbotsford Aquifer

Evidence of overfertilization in the Lower Fraser Valley: nitrate levels in water drawn from a well in the Abbotsford Aquifer



The Sumas River, which receives runoff from intensively farmed land above the Abbotsford aquifer, was studied by FRAP. Results show elevated nutrient levels (nitrogen, ammonia, and phosphorus), as well as fecal coliforms and low oxygen levels. High levels of copper and zinc were also detected, which scientists suspect may come from hog feed. In parts of the Sumas Basin, frogs' eggs no longer hatch, an indication of possible contamination. Such indications imply that a substantial load of surplus agricultural nutrients is seeping into the water table and running into the streams in agricultural areas.

The ammonia component from manure turns the otherwise yellow-brown smog into a milky haze

White haze

A white haze is experienced on calm, sunny days in the eastern parts of the Lower Fraser Valley. Scientists have confirmed that the haze is a rural version of urban smog. Industrial pollutants and vehicle emissions, from local and distant sources, combine with tiny particles incorporating ammonia from manure which have spread through the air from barns, stockpiles, and cropland. The ammonia component from manure turns the otherwise yellow-brown smog into a milky haze. This haze, whose full effects on human health are not yet known, aggravates respiratory problems for some of the people who inhale it.

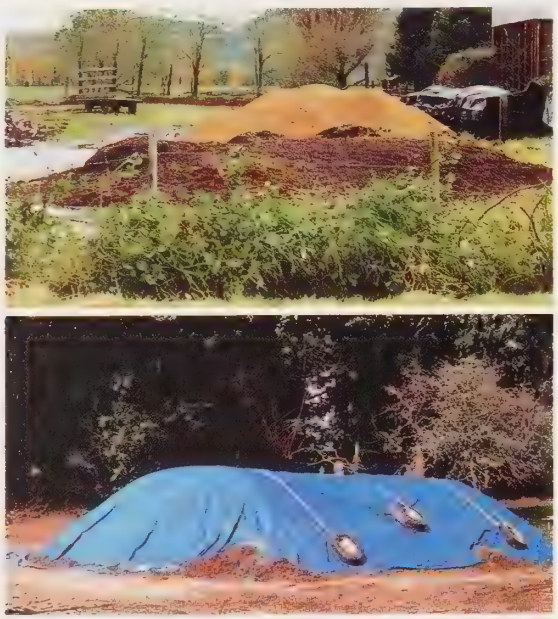
Modelling nutrient pathways

To find the sources of nutrient contamination, FRAP cosponsored a set of studies of agricultural nutrient management. The studies developed nutrient-balance models based on a simple observation: in an agricultural area, nutrients enter in animal feed and commercial fertilizer and leave in crops and animal bodies. If more nutrients enter an area than leave it, the result will be a surplus of nutrients which will build up and start moving into the air and the water.

Twenty agricultural zones were identified in the Lower Fraser Valley, and for each zone the inputs, transfers, and outputs of nitrogen, phosphorus, and potassium were modelled, using 1991 census data on fertilizer use, livestock numbers, and crop production. An exact balance of nutrient input (livestock production plus fertilizer use) with crop removal was not expected. A small surplus would be consistent with careful management to ensure that the soil was not being depleted of these nutrients. But prudent management would try to keep this surplus low. With nitrogen, for example, the surplus should not exceed 50 kg per hectare per year at the very most.

The studies found large surpluses in many zones. For nitrogen, 16 of the 20 zones, representing 78 per cent of the total cropped area, exceeded the 50 kg/ha/yr prudent maximum. In fact 10 zones, representing 57 per cent of the cropped area, had surpluses of more than 100 kg, that is, more than twice the maximum. Three zones, representing 11 per cent of the cropped land, were at the top: South Langley 108 kg, West Matsqui

New technology carefully regulates fertilizer application.



Better manure handling (below) keeps rain from leaching nitrates into surface and ground water.

202 kg, and, highest of all, South Matsqui 308 kg, or six times the maximum. Interestingly, South Matsqui sits on the vulnerable Abbotsford aquifer.

With phosphorus and potassium, the balance was measured as a ratio of the total input to the amount removed in the crops. Again, any difference would be remaining residue, which should prudently be kept low. In almost all cases, surpluses were large. With phosphorus, total input was at least twice as much as removal in 18 of 20 zones, and more than four times as much as removal in six zones. With potassium, total input was at least twice as much as removal in 12 zones, and more than three times as much in three zones. Once again, South Matsqui showed the highest surpluses, with input more than 12 times removal for phosphorus and more than five times removal for potassium. Again, West Matsqui came second.

The models are of course only approximate, and the results, being based on zonal averages, do not apply to particular farms. Nevertheless, the results in both cases create an unequivocal conclusion: a massive overloading of nutrients is occurring in Lower Fraser Valley agriculture.

Furthermore, as another FRAP study concludes: "because the residence time of groundwater in the Abbotsford aquifer is on the order of decades, high levels of nitrate will persist for many years even if the nitrate sources are eliminated."

To gain a closer understanding of the role of agriculture in water quality, a FRAP-sponsored study is under way, tracking changes in agricultural practices with changes in water quality conditions in the North Matsqui zone.

Poultry and livestock farming create huge quantities of manure for which there is no use

The nutrient models showed a second surprising result. They differed in their assumptions about how much of the surplus nitrogen would volatilize into the air and therefore how much would be left in the soil to get into the water. These modelled losses to the air alerted FRAP staff to the possible connection with white haze and led to the studies confirming the connection.

Berry crops require even less manure than forage crops.

Surplus manure and changing crops

FRAP studies indicate that, though both manure and commercial fertilizer are sources of excess agricultural nutrients, manure accounts for the largest quantity. The reason is that the many sites of intensive poultry and livestock farming in the Valley create huge quantities of manure for which there is no use. This manure is stockpiled, is often handled casually, and is available at very low prices, or free, to crop farmers.

A second factor contributing to the nutrient surplus is a general shift away from forage crops, which use a lot of nutrients, to berry crops, which need much less. Often the change in crops is not reflected in a corresponding reduction in rates of application.

FRAP RESPONSES TO NUTRIENT SURPLUSES

Improving agricultural practices

In agriculture as in other sectors, FRAP and its partners encouraged more environmentally aware management. They have supported the development and implementation of Best Agricultural Waste Management Plans (BAWMPs) for all Lower Fraser Valley farms. Such plans identify environmental problems on the farm, evaluate and recommend alternative solutions, and encourage the implementation of improvements. Some farms in the area have already adopted BAWMPs.

In relation to manure, a comprehensive BAWMP would address utilization and conservation, handling and storage, and off-farm movement. The goal would be to establish sustainable nutrient balances. Helping farmers develop their plans will require education, promotion, and regulatory enforcement.

Best practice, like this storage compound under construction, completely isolates the manure.

There are also technical issues that need further research and guideline development in many areas of farm practice, from cropping methods, to feeding strategies, to buffer strip and riparian area management, to optimal nutrient application rates and timing by crop and location.

Poultry growers take the initiative to move excess manure to farms in areas of manure deficit.

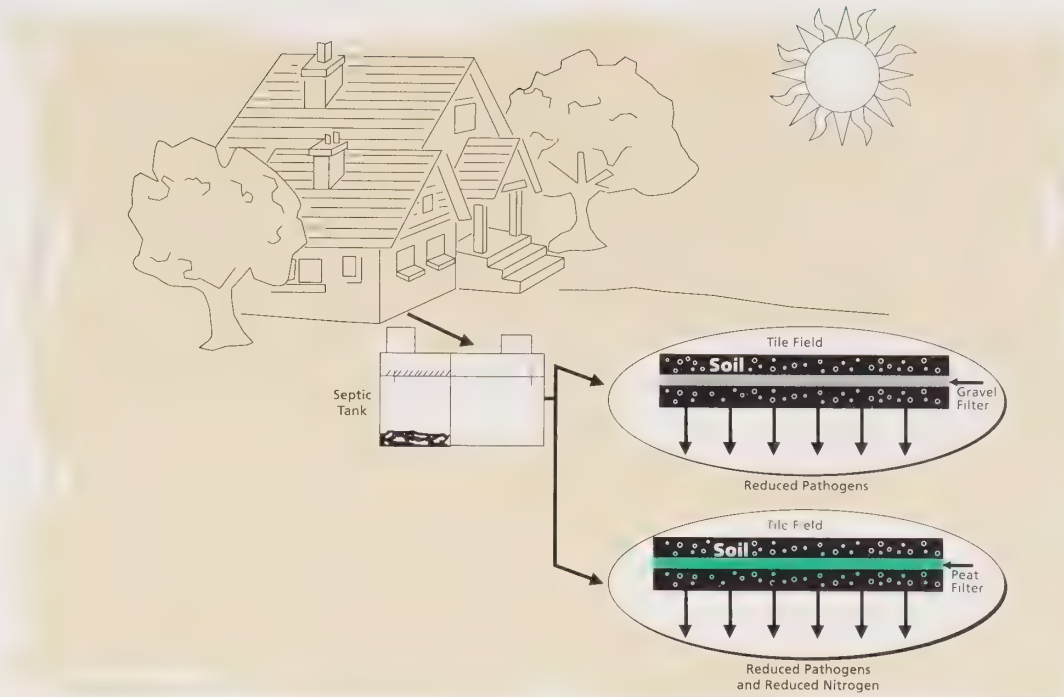
Manure transport and marketing

A direct way to deal with a manure surplus in one area is to truck the excess to other areas where nutrients are deficient. FRAP funding has helped support a program by the Sustainable Poultry Farming Group to do just that. The program aims to set up a financially self-sustaining system to remove up to 44 per cent of the excess poultry manure produced each year in lands above the Abbotsford aquifer and distribute it to farms elsewhere in the Lower Mainland and the interior. In 1997, the program reached a removal rate equivalent to about 19 per cent of total annual production.

This surplus-export approach will require marketing to find customers. An initial study sponsored by Agriculture Canada's Agricultural Green Plan looked at opportunities for marketing poultry manure outside the Lower Mainland. Among the possibilities was that of developing a high-value fertilizer that could be useful on golf courses and turf farms. In partnership with provincial and federal government partners, FRAP supported a follow-up assessment of market opportunities for a pelleted and crumbled composted poultry manure fertilizer. The study considered several N:P:K formulations, costs, prices, quantities, and markets. It concluded that high-end customers would be interested, but to make a processing plant attractive, markets outside the province would also have to be found.

Improved septic systems

The concern for organic nutrients in the Lower Fraser Valley drew attention to human waste as a possible contributing source. In most rural areas, traditional septic systems are used. FRAP recognized the environmental limitations of such systems. Because their performance is degraded with poor maintenance, public information materials and maintenance guidelines were prepared. Properly functioning septic systems are very effective at removing pathogens and protecting human health. But they do not remove much nitrogen from household effluents.



To remove nitrogen, a standard septic system requires the addition of nitrogen-trapping materials (eg peat) in the drainage bed.

FRAP therefore commissioned a study of improved kinds of septic systems (from a nutrient-removal standpoint) and their cost-effectiveness as replacements or add-ons. After a comprehensive review and exploration of alternatives, the report recommended a number of options which were quite cost-effective at removing 70 to 80 per cent of nitrogen, compared to only 10 per cent with traditional systems. The capital cost of these systems, all under $10,000, could be reduced further if local materials, such as peat, proved suitable for them.

The report also pointed out that engineering consultants and system installers would need to learn more about nitrogen-removal to make these alternative technologies effective. FRAP, in partnership with the B.C. Onsite Sewage System Association, is sponsoring a workshop on the alternatives for installers, consultants, and government regulators. The workshop will be held in October 1998 in conjunction with the opening of a new training facility for onsite sewage treatment system design at Royal Roads University in Victoria.

DUCKS UNLIMITED CANADA

MIDDLE AND UPPER FRASER

In the broad interior expanses of the Fraser Basin, agricultural production is dominated by cattle ranching. Public awareness is growing about the environmental damage certain ranching practices have been causing. As early as 1981, a Thompson Basin Task Force pointed out that livestock operations, feedlots, overwintering of cattle beside streams, and removal of vegetation from stream banks were causing numerous water quality and stream degradation problems throughout the basin. In the early 1990s, studies of the Cariboo-Chilcotin emphasized similar issues in that region.

Protected areas are improving, wildlife is benefiting, and ranchers are pleased with improved cattle health

As in the Lower Fraser, FRAP's efforts in these areas focused on habitat conservation and pollution. Both issues are of concern to residents in the Middle and Upper Fraser Basin.

Left–Fallis Pond: a demonstration wetland restoration and cattle-watering facility near Kamloops

HABITAT PROTECTION

In the less populated areas of the provincial interior, the leading habitat concern is rehabilitation and protection from degradation.

Interior Wetlands Program

Out of primary concern for migratory birds, the Interior Wetlands Program was launched in 1992 through a partnership between FRAP, three provincial ministries (Environment, Forests, Agriculture), and Ducks Unlimited Canada, the latter being primarily responsible for managing the program. Looking at grasslands and open forest rangelands, the Program emphasizes habitat conservation and improvement, water quality and quantity, and sustainable agriculture. Habitat objectives encompass both wetlands and riparian vegetation, and the focus is on working with ranchers to improve management practices.

By early 1998, about 1375 hectares of wetland and 6344 hectares of upland habitat had been brought under improved management in 23 demonstration projects secured by 30-year landowner agreements. Many projects involved improved cattle watering facilities and fencing to keep cattle out of

ANDRE BREAULT

sensitive wetlands. The protected areas are recovering, wildlife is benefiting, and ranchers are pleased with improved cattle health and productivity as well as secure water supplies. Ducks Unlimited estimates the improvements will support an additional 2500 waterfowl every year.

These habitat restoration practices are exemplified by two projects near Merritt, in the Middle Fraser Basin. At Peter Hope Lake, water withdrawals for irrigation during summer months used to cause the lake level to drop, exposing mud flats in which cattle would wallow and drying up valuable wetland habitat around the lakeshore. The irrigation system was also inefficient, with only 10 per cent of the water arriving at the desired destination in a clouded and unhealthy condition. In 1994, FRAP and partners worked with the local landowner on a

Too often, wintering cattle are allowed direct access to watercourses.

rehabilitation plan in which fences and cattle guards kept grazing cattle from the lake edge and associated uplands. A new well, pump house, and watering facility were constructed to supply year-round clean water for cattle.

The wetland has returned and the lake is once again renowned as a fishing site for Kamloops trout.

Nearby, the meandering Nicola River has created an oasis of marshy oxbows and fertile floodplain within the dry southern interior landscape. Over the years, the lush ribbon of cottonwoods, shrubs, and thick grasses that bordered the river was stripped away for agriculture and other land uses. The river banks began to erode and collapse, affecting water quality and fish habitat, while the overgrazed riverbanks provided little cover, food, or breeding areas for birds and other wildlife. In the floodplain, cultivated crops had replaced native vegetation. FRAP and partners worked with local landowners and

a community school to launch a rehabilitation project. Dikes and drainage channels control floodwaters; natural inlet channels have reopened oxbows to river water; passages of open water allow waterfowl to alight and feed; wire mesh protects surviving cottonwoods from beaver; new vegetation along the banks reduces erosion, provides shade for fish, and rebuilds the bank by trapping sediments. With these and other improvements, the riparian habitat and diversity of this reach of the Nicola River is rapidly restoring itself.

To raise awareness and understanding of wetland conservation and sustainable agriculture, the Interior Wetlands Program has produced many publications: brochures, stewardship guides, posters, a newsletter, a web site, a video, and profiles of every demonstration project. These materials were distributed and advertised widely among the ranching community, government agencies, and the general public. Workshops on wetland management were held with participants from the ranching community, conservation groups, government, and the interested public. Cooperation and partnerships among participants and their constituencies have been promoted by the extensive activities of the Program.

FRASER BASIN COUNCIL

Nicola River

Opportunities

Some ranchers foresee non-agricultural opportunities resulting from sustainable practices. To help investigate some of these, FRAP sponsored an analysis of opportunities for the Douglas Lake Ranch to capture increased tourist revenues. The study concluded that there is an increasing market for ecotourism activities such as bus trips and guided tours. These activities do not generally conflict with the cattle operations if managed carefully. But to take advantage of this market the ranch must protect and enhance its wildlife and natural ecosystems.

Of particular importance is edge habitat between grasslands and forests and riparian zones between grasslands and water bodies. Among other things, these zones provide cover for game birds. The study suggested that the Douglas Lake Ranch could develop a stocked gamebird shoot that would increase the occupancy season of lodge operations currently geared mainly towards recreational fishing.

Other ranchlands in the Basin could similarly develop tourist revenues by protecting biodiversity, controlling access, and separating cattle operations from touring, hunting, and fishing.

FRASER BASIN COUNCIL

Watershed restoration: a foundation is laid for new riparian growth.

WATER QUALITY AND COMMUNITY ENVIRONMENTAL MANAGEMENT

The deterioration of water quality caused by common agricultural practices is an issue in many interior communities. Broad use of the practices, and their embeddedness in community life, demonstrate why management for sustainability requires local leadership. Ending damaging practices and making needed improvements will mean that some community habits must change.

These changes cannot be imposed from outside, and not only because of the resentment and opposition such an attempt would create. The real reason that the change must come from within is that the essence of managing for sustainability is to take responsibility. Community members must understand that their well-being and the quality of the landscape in which they live is ultimately theirs to determine – and in fact that they are the only people who combine the local knowledge with the commitment needed to make the changes that will sustain their desired way of life.

Understanding the fundamental nature of community initiative, FRAP and its partner agencies accepted that sustainability was something they could advocate, facilitate, and support but not something they could legislate, regulate, or in any way accomplish from outside by themselves. Yet one vital kind of help they could give was to encourage forms of community environmental planning and decision-making that arose locally.

For example, FRAP supported a consensus-based community planning initiative in Salmon Arm. Though forestry and recreational activities occur in the area, it is mainly a diversely agricultural region of dairy farming, ranching, and crop production. Many community residents had for years been active in stream restoration projects, concerned about a decline in salmon populations and in water quality and quantity. In 1993, some restoration groups came together to create a community-wide umbrella organization

FRAP supported a community planning initiative in Salmon Arm

called the Salmon River Watershed Roundtable which would take a holistic, ecosystem approach to managing the whole Salmon River watershed.

The members were diversified. Partners and participants included residents, farmers, environmentalists, sawmill owners, community organizations, First Nations, local

Showing a resident how to take benthic samples to monitor river quality

businesses, and representatives from all levels of government. Their goal was to try to find among their differences the common ground that would make the Roundtable a knowledgeable and effective watershed manager.

With FRAP's help, members learned about environmental interactions and how to monitor them. By joining their local knowledge to scientific findings they gained a practical understanding of the workings and problems of the watershed. Deliberating over issues, learning to empathize with alternative perspectives, and negotiating solutions to conflicts, the Roundtable members gradually developed a set of goals and objectives for the watershed which reflected a consensus vision for the future. Much more than a wish list, these objectives resulted from an informed understanding of the changes and efforts needed to realize them and a determination to move ahead with them.

The project succeeded in bringing the community together, surmounting their differences, in support of a shared vision. It showed the power of a watershed management approach to bring conflicting interests into effective cooperation.

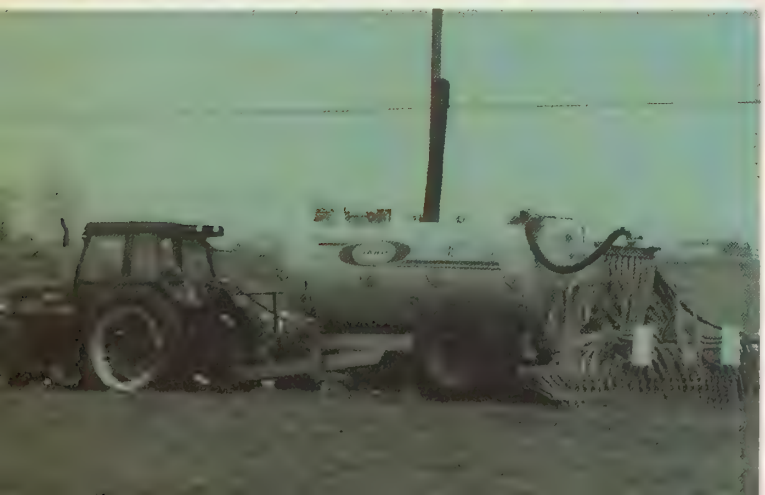
The Salmon River Watershed Roundtable provided many lessons for participants and observers about dealing with government agencies and their institutional differences, about the importance of commitment and the dangers of volunteer exhaustion and burnout, about the need for communication and education as well as for positive feedback and recreation. The project generated a well-organized decision-making process based on community participation; it educated local residents about their watershed and its issues; and it encouraged a variety of initiatives, including re-establishment of 10 per cent of the riparian corridor along the Salmon River.

Attention is now shifting from habitat enhancement to agricultural practices. Water quality monitoring shows increasing concentrations of fertilizer residues, particularly phosphorus, as well as growing turbidity. It seems likely that the intensive irrigation in the watershed is increasing runoff and contaminant flows in groundwater. As in the Lower Fraser Valley, agricultural practices in the Salmon River watershed will come under increasing scrutiny.

The Salmon River Watershed Roundtable has not been alone in attempting watershed management. The Nicola River Watershed Committee, the Quesnel River Watershed Alliance, the Chilliwack Watershed Alliance, and emerging groups in communities along the Squamish and Coquitlam Rivers provide other examples of community groups that apply similar principles to local environmental issues.

WHAT'S NEXT

The agricultural sector faces growing competition both in markets for its products and for arable land. Farmers face strong incentives to resort to non-sustainable practices for short-term survival. FRAP studies have shown that environmental management is an indispensable part of sustainable agriculture. Important early steps have been taken in identifying forms of deterioration and alterations in farming practice that could correct them. Basin residents and stakeholders, including Environment Canada, must continue to work with farmers and ranchers on developing best practice guidelines, environmental management plans, and other methods of making decisions on farming practices which are sustainable and friendly to fish and wildlife.



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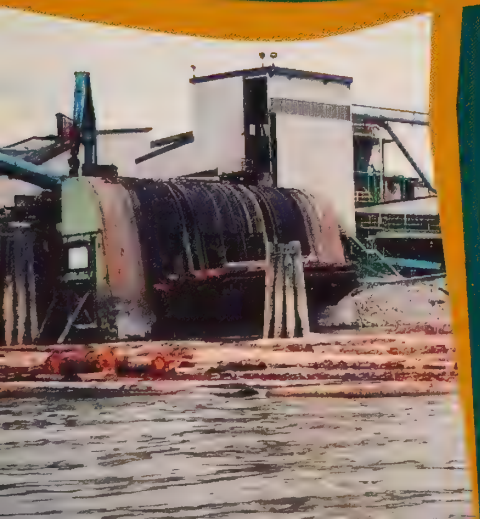

FRASER RIVER
ACTION PLAN

Canada

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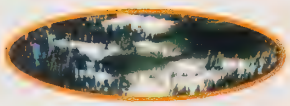
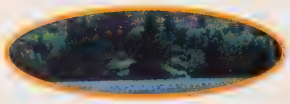
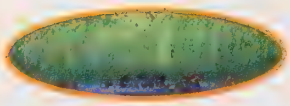






FRASER RIVER BASIN

FOREST INDUSTRIES AND THE ENVIRONMENT

Traditionally a mainstay of British Columbia's economy, the forest industries have three main branches: logging, lumber mills, and pulp and paper mills. These activities differ in their effects on the natural environment:

- Logging can degrade or eliminate fish and wildlife habitat. Clearcuts and logging roads can fragment and remove habitat, promote erosion, clog streams with debris and sediment, and destroy riparian vegetation and spawning beds. The Forest Practices Code of the 1990s represents a cooperative effort by the logging industry and government to reduce unnecessary destruction in forested areas.

- The mills generate toxic residues which find their way into the environment as pollution. Liquid pulp mill effluents are discharged to rivers. Fungicides and wood preservatives used in lumber products can seep into groundwater or run offsite into streams. Pulp mill gases diffuse into the air, as any passerby can tell from the odour. Airborne gases and smoke eventually join the water contaminants when they are washed from the air by rain. In the 1990s, both lumber and pulp and paper mills undertook a huge pollution reduction and cleanup effort.

EC AQUATICS SECTION

When the Fraser River Action Plan (FRAP) came on the scene, substantial programs in improved management and clean-up were already underway in the B.C. forest industries to reduce their environmental impacts. FRAP scientists helped track both the harm caused by the old practices and the improvements made by the upgrades. Staff worked with industry to extend the improvements and to enhance public awareness of the environmental values at stake.

EC AQUATICS SECTION

FOREST INDUSTRIES CUT POLLUTION

In the last 10 years, the forest industries have reduced significantly the amount of toxic effluent they release into the Fraser Basin.

Freshly cut softwood lumber is treated with anti-sapstain chemicals that can be highly toxic

DIOXINS AND FURANS

In 1992, the federal government, responding to growing scientific and public concerns, introduced much more stringent pulp and paper effluent regulations. These required mills to reduce drastically the amounts of dioxins and furans produced by bleaching processes using new technology. The industry in B.C., which had been in the forefront of developing and implementing this new technology, has now managed to reduce the amount of dioxins and furans in effluent by 99 per cent. Pulp and paper mills within the Fraser Basin were in full compliance with the new regulations by 1996.

FUNGICIDES FOR SOFTWOOD LUMBER

Freshly cut softwood lumber is susceptible to "sapstain" moulds and fungi and therefore is routinely treated with anti-sapstain chemicals that can be highly toxic to fish (eg sturgeon fry). In British Columbia, about 70 per cent of the softwood lumber industry is in the Fraser Basin. Traditionally, lumber companies would dip pallets of lumber in vats of inexpensive anti-sapstain solutions and then store the wood outdoors, where the chemicals could be washed away by the rain. Little attempt was made to keep these residues from reaching ground or surface waters.

In response to public concerns, new provincial regulations, and intensified government enforcement efforts, the industry invested about $80 million in improved treating facilities and less toxic chemicals. Recycling of chemicals was encouraged by the much higher price of the replacement chemicals. As a result, between 1988 and 1992, the softwood lumber industry reduced its monitored effluent discharge by 99 per cent (from 260 million to only 1.6 million cubic metres a year), and better containment prevents the chemicals from leaking into groundwater or runoff.

With modern technology, heavy duty wood preservation can be a very clean operation. ZAHEER MANKI

A 1996 FRAP inspection program rated the implementation of best management practices in the industry at 87 per cent. However, there is new concern that the replacement chemicals, believed in 1991 to be less toxic than the traditional ones, may also be harmful.

HEAVY DUTY WOOD PRESERVATION

Wood intended for use outdoors in stressful environments, such as railway ties, telephone poles, and dock pilings, is impregnated with preservatives, such as creosote. The pressure-treated wood was traditionally left to cure in an open yard. There are 14 heavy duty wood preservation operations in the Fraser Basin (19 in all of B.C.). In 1990 they generated an estimated 600,000 cubic metres of toxic surface runoff annually.

From 1992 to 1997, FRAP invested about $600,000 in a compliance and enforcement program, and the mills invested about $39 million to upgrade their facilities. Storage areas are now paved, and runoff is collected and recycled. A 1996 inspection program concluded that the implementation of best management practices had reached 89 per cent. By 1997, annual environmental releases in the Fraser Basin had been reduced by 95 per cent to 30,000 cubic metres.

WATER POLLUTION FROM MILLS

CONTAMINANTS

Dioxins and furans are highly toxic chemicals, very low doses of which appear to cause cancer, birth defects, and harm to endocrine functions in humans and animals. In the 1980s, scientists found an association between dioxins and furans in the tissues of Great Blue Herons and a decline in the birds' breeding success. In recent years their body loadings of these contaminants have decreased and they are better able to reproduce.

FRAP studies also showed that the decline of dioxins and furans in heron tissues has been paralleled by declines of more than 90 per cent in the tissues of other birds and fish and in sediment. All the decreases have occurred since 1991, when pulp mills began changing their bleaching processes. Corresponding to this improvement in best practices and technology, regulations were tightened in 1992. By 1996, all mills in the Fraser Basin were in compliance with the tighter regulations.

When FRAP began its work in 1991, studies of a broad range of wastewater sources showed that pulp and paper mill effluent discharges were the major source of BOD and TSS. These are two indicators of general pollution levels: biochemical oxygen demand is a measure of organic content and total suspended solids are a measure of floating particles. Other pollutants are often found in association with these.

FRAP studies also demonstrated that effluent from the forest industry mills remains a source of a variety of contaminants: metals (zinc, chromium, copper), polycyclic aromatic hydrocarbons (PAHs), resin acids, and chlorophenolics, as well as traces of dioxins and furans. Wastewater from smaller sawmill operations was found to be putting arsenic into the river, while one sawmill was releasing zinc.

FRAP-supported monitoring has shown that the pulp and paper mills have also reduced BOD by 38 per cent and TSS by 39 per cent from 1991 to 1996.

EC AQUATICS SECTION

ECOLOGICAL EFFECTS

FRAP scientists have pioneered in monitoring benthic (bottom-dwelling) organisms for clues to pollutant effects. These shellfish, worms, insect larvae and other macroinvertebrates are the means by which pollutants move from sediment into the food chain to reach fish and birds, and their community interrelations and relative populations can readily show symptoms of pollution. But such population changes can also reflect the combined result of a variety of impacts within which the effects of pollution may not be easy to distinguish.

NHRI

Retrieving a study sample from a mesocosm

For example, FRAP studies found that the benthic macroinvertebrate communities downstream from the pulp mill at Prince George showed signs of disturbance when compared to similar communities in pristine water. This disturbance was likely caused by pollution from the mill. But it might also have been influenced by other changes along the river that affected the sediment as a habitat at the sample site.

EC AQUATICS SECTION

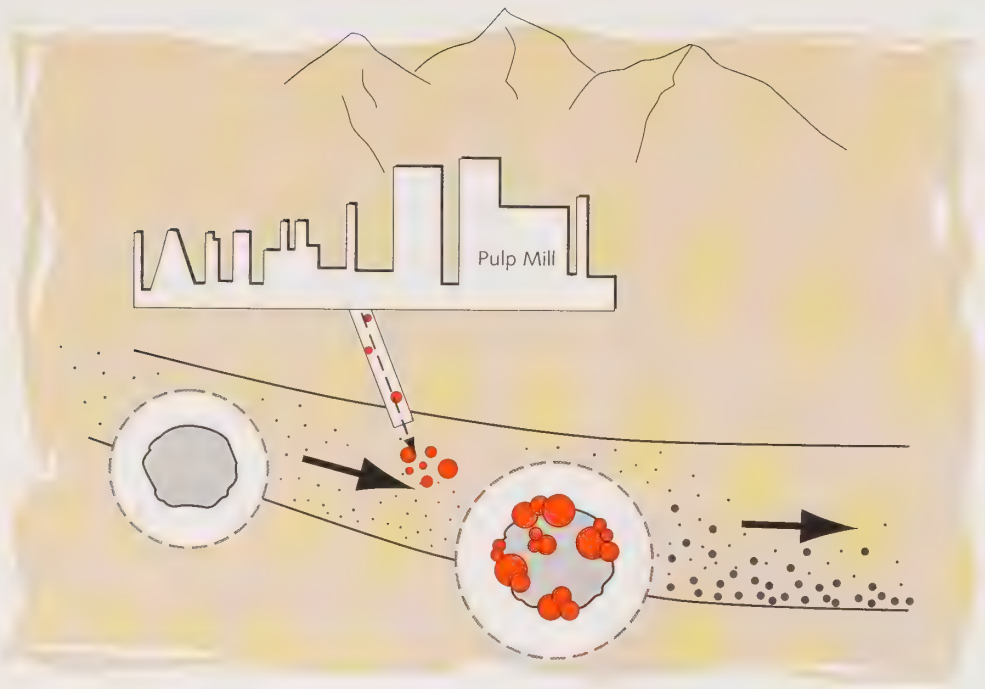
Collecting benthic organisms for environmental monitoring

FRAP scientists also developed a mobile tool for experimental analysis of industrial effluents. Called a mesocosm, it puts populations of benthic organisms in open-air tanks which can then be filled with varying effluent concentrations in controlled conditions of temperature, duration, agitation, etc. The mesocosm experiments confirmed that pulp mill effluents can affect such populations. At effluent-to-river-water concentrations of 1 to 3 per cent, which can be experienced in the river at low flow conditions, the organisms showed extra growth apparently due to nutrition. At somewhat higher concentrations (5 per cent), the organisms showed no extra growth and exhibited symptoms of toxicity.

FLOCCULATION

Contaminants often adhere to particles and therefore travel with suspended sediments. Suspended particles tend to settle out in quiet water, while swift water can lift them from the bottom and get them moving again. Larger particles settle faster, and particles can get bigger by flocculating (clumping together). Any substance that promotes flocculation will thus accelerate sedimentation.

FRAP studies show that pulp mill effluents promote flocculation. Suspended sediment collected upstream of a basin pulp mill



Effluents encourage particles to stick together and settle out.

typically consists of fine, single particles, whereas suspended sediment collected downstream of a mill will have a significant fraction of larger, flocculated particles.

FRAP studies show that pulp mill effluents promote flocculation

These aggregate particles will settle out sooner than the single particles, especially in low flow conditions during the fall and winter. Therefore the area downstream of a pulp mill tends to receive deposits of sediments affected by mill effluent.

Since mill contaminants tend to adhere to particles, the intensified sedimentation downstream of pulp mills means a greater concentration of chemicals in the riverbed sediment in those locations and therefore a greater effect on benthic organisms who live in and feed on those sediments. These effects will be most pronounced where flows are low, that is, in backwaters rather than swiftly running reaches and in fall and winter rather than spring and early summer.

Another indicator of localization in pollution can be found in osprey, which eat fish and can show the effect of biomagnification of contaminant concentrations going up the food chain. During 1992–94, FRAP scientists counted the numbers of hatched eggs and measured fledgling success in osprey nests, comparing nests upstream from pulp mills with those downstream. Only in the first of the three years did there seem to be

a small advantage for young birds to live upstream. The researchers concluded that the effect was not great and was diminishing, probably reflecting the effluent clean-up occurring at the time.

Scientists also detected pulp mill contaminants in bed and suspended sediments and in the tissues of fish, tree swallows, mink, and river otter. The levels were low enough to be thought safe, but the findings indicate the ease with which pollutants work their way through living systems.

RALF BÜRGLIN

REPLACEMENT CHEMICALS

To kill moulds and fungi, lumber mills used highly toxic PCP (pentachlorophenol) until it was banned in 1991. Having experimented with some less toxic substitutes, the industry has come to rely heavily on two, DDAC and IPBC, which now account for 90 per cent of anti-sapstain use in B.C.

These replacements are only 1/20th as toxic to fungus and mould as PCP, so industry is using more of them. In 1987, the annual consumption of the chemicals used in anti-sapstain processes was 300 to 400 metric tons a year. By 1994, three years after PCPs were banned, the amount had risen to 846 metric tons. By 1997, well over 1000 metric tons were being used. DDAC has become the third most heavily used pesticide in British Columbia.

But DDAC illustrates the uncertainties involved in trying to determine the danger posed by a pollutant. DDAC is more toxic to some life stages of species than to other stages and species. FRAP researchers have found DDAC to be highly toxic to sturgeon in its early life stages (40 to 60 days old), though less so to some other fish, such as the starry flounder, found in the same parts of the Fraser estuary. There is also evidence that DDAC adheres readily to particles and gets deposited quickly. This reduces its direct exposure to fish in the water but raises concerns about concentrations in sediment settling areas.

Because of these concerns, a DDAC water quality guideline for the protection of fish and invertebrates is being reviewed by the Canadian Council of Ministers of the Environment. Meanwhile, scientists want to know more about the distribution of DDAC-sensitive fish at different life stages.

They want to be sure that laboratory tests aren't missing something, such as species with unexpected sensitivities or pockets of sediment with concentrations much higher than the proposed guideline. When a guideline is adopted, more stringent limits on effluent concentrations may be needed for the Lower Fraser where the chemical is most widely used.

Researchers have found DDAC to be highly toxic to sturgeon in its early life stages

The lumber industry is understandably concerned about more restrictions on the use of a chemical on which it relies so heavily. The chemical's manufacturer is also concerned because DDAC is being introduced in the Great Lakes to control the zebra mussels that clog water intakes of industries, municipalities and power plants.

WOOD WASTE

A FRAP inventory established that the lumber industry accounts for about one-fifth of the 4.3 million cubic metres of unused wood waste generated annually in the Fraser Basin. This fraction is diminishing rapidly as the industry adopts recycling. With provincial regulations phasing out beehive burners, lumber companies increasingly divert former wood waste into pulp chips, cogeneration projects, livestock bedding, and remanufactured products, leaving only bark and very rough material as residues.

Analyses of the types and sources of wood waste and of potential uses for it have helped encourage greater recycling.

EC AQUATICS SECTION

Forest industry waste is increasingly converted to useful products (pulp chips, fuel, particle board).

RIVERSIDE FOREST PRODUCTS

RIVERSIDE FOREST PRODUCTS

Sustainability will increasingly depend on the efforts of individuals and private companies. FRAP pollution abatement staff worked with private companies to promote sustainability initiatives.

One example comes from Riverside Forest Products, owner of the mid-sized Williams Lake Sawmill, which produces kiln-dried dimension lumber. The company undertook a pollution prevention planning process, involving a public advisory committee, which generated 48 options for consideration. The company intends to implement all but eight. The plan includes targets and a monitoring process to track implementation.

Highlights include:

- Reducing vehicle emissions, greenhouse gases, and road dust, through on-site speed limits, vegetation windbreaks, dust suppression, and a shift to propane fuels.
- Combatting riparian habitat erosion through stormwater management planning, culvert upgrading, and water conservation measures.
- Reducing contaminant releases by cleaning up old equipment, minimizing lubricant use, using biodegradable hydraulic oils in high-risk areas, replacing underground tanks with above-ground double-walled tanks, separating oil/water/sediment in waste streams, implementing a hazardous materials management plan, and eliminating onsite sewage disposal.
- Managing wood waste by cutting in half the volume of wood waste landfilled by 2000, introducing new equipment to reduce log handling and therefore waste, and covering a portion of the landfill to reduce leachate.
- Reducing plant noise by eliminating outdoor shift whistles, improving chip blower procedures, and lining metal conveyor troughs with plastic to reduce metal-to-metal contact.

This example of forward-thinking environmental management shows how a company can voluntarily keep pace with best management practices.

HABITAT CONSERVATION AND FOREST PRACTICES

The effects of forest practices on habitat can be complex. Sometimes the destruction of one kind of habitat creates a new and different kind of habitat. Advocates of clearcutting, for example, argue that it actually leads to diversified vegetation as new growth sequences spring up, encouraging different animal and bird populations than flourish in mature forests. Opponents of clearcutting counter that such changes are outweighed by the habitat destruction caused by removal technologies for bulk fibre. In British Columbia these are controversial topics, with many nuances to be considered.

FRAP has sponsored a wide range of activities to research issues, encourage environmentally sensitive forest practices, and protect sensitive areas.

HABITAT RESEARCH

FRAP sponsored a number of studies to develop a better understanding of how birds use forested areas and how forest practices can affect them. FRAP support was essential to the extensive field research. The results will be published in scientific journals and reports, will be made available to resource managers and planners and the forest industry, and will help in the design of forest management guidelines.

KATHLEEN MOORE

Here are descriptions of several of these studies:

Habitats are not created equal

In British Columbia the forests consist mainly of conifers. However, areas that are logged or burned by forest fires are rapidly recolonized by broad-leafed, deciduous trees. Since they are of less economic value and are believed to compete for space, light, and water with the slower-growing conifers, foresters tend to regard them as weeds and remove them to accelerate conifer growth. Sometimes they then spray the stumps with herbicide to prevent regrowth, permanently removing deciduous trees from the landscape. Such practices affect bird species that depend on the broad-leafed trees for forage, shelter, and concealment from predators.

The removal of broad-leafed vegetation drove away species dependent on it

A four-year experiment sponsored by FRAP was conducted in young conifer plantations near Salmon Arm to investigate the effects of removing deciduous trees on breeding songbirds. In designated areas, broad-leafed trees were cut down with power saws. In some plots, the stumps were left alone and were soon sprouting vigorously. In other plots, the stumps were sprayed with the herbicide glyphosate to prevent regrowth. In control plots, the deciduous trees were left untouched.

The removal of broad-leafed vegetation drove away species dependent on it. However, as the deciduous stumps resprouted in the manually thinned plots, the deciduous-dependent species returned, showing their flexibility in dealing with habitat changes. They even increased in number and improved their nesting success.

The herbicide-treated plots were a different story. The broad-leafed vegetation did not return, and the bird community was transformed. There were more birds of common generalist species that prefer to feed in open forests. But birds dependent on broad-leafed vegetation had disappeared, and there were fewer species overall. Permanent removal of deciduous trees thus encouraged bird species that were already very common.

A more alarming finding was that the common species that came to predominate in herbicide-treated areas had great difficulty raising their young. These areas no longer were able to support a self-sustaining bird community. The numerous common birds in the herbicide-treated plots were immigrants, born elsewhere, able as adults to take advantage of the plots but unable to reproduce there. Therefore even the few generalist species that seemed to benefit from the herbicide treatment were at long-term risk.

Another study in the same area has cast doubt on the belief which justifies the removal of broad-leafed trees in the first place: the idea that deciduous trees compete for resources

with conifers. Scientists have found that conifer seedlings benefit from the presence of deciduous trees by the intake of nutrients through interconnected root systems. So commercial conifers, as well as birds, may benefit from the maintenance of deciduous trees in conifer plantations.

Riparian riches: the value of streamside habitat for birds

The shoreline of a lake, pond, stream, or river has moist and fertile soil supporting lush and varied vegetation not found farther from the water. This riparian vegetation usually offers a wide selection of food for animals and abundant cover and nesting sites. Wildlife surveys show that in British Columbia, a majority of wildlife in a landscape relies on this waterside environment. But most studies have taken place in southern areas of the province, and the value of riparian habitat in more northerly parts of the Fraser Basin was largely unexplored.

In all seasons, the riparian zone supports a greater density of birds than the forest

A study in the coniferous forest of north-central British Columbia observed the species of birds using streamside habitat and analysed changes in patterns of use through the seasons. At the study sites on

A forest in the Stuart Lake / Takla Lake region

Chipping Sparrow

some streams near Takla Lake, north of Fort St James, the upland conifer forest grew right to the water's edge, and the riparian zone consisted of a dense deciduous understory of alder, dogwood, and willow.

In two years of observation, 77 bird species were identified. Of the 46 most common species, one quarter were year-round residents and three-quarters were migratory. Four kinds of habitat preference were observed:

- Riparian breeding: during the summer breeding season some species build nests in the streamside bushes, concealed from predators.
- Riparian migration: some species frequent the rich streamside food sources when fattening up for long-distance travels, but for breeding they prefer to nest in trees.
- Generalists: with a broad diet, some species find food and shelter easily anywhere in the forest, so they neither prefer nor avoid the riparian zone.
- Non-riparian: some species nest and forage high in the forest canopy or in the open forest floor and avoid the low, dense riparian shrubbery.

Most generalists and non-riparian species are year-round residents. However, the birds that breed or fatten in riparian zones in warmer seasons tend to be migratory, and they are attracted to the riparian areas by their richness in forage and shelter. The heavy use of riparian zones by migratory birds suggests that these narrow bands of habitat may function as corridors — migration highways — through the coniferous forest.

Overall, the riparian zone has more species than the surrounding forest in spring and fall, though not in summer or winter. But in all seasons, the riparian zone supports a greater density of birds than the forest.

ERVIO SIAA

Golden-crowned Kinglet

ERVIO SIAA

Black-capped Chickadee

Cavity-nesting bird communities

Many birds (and some squirrels and bats) nest in cavities in tree trunks. A FRAP study in the Cariboo-Chilcotin region of the Fraser Basin identified 32 species of cavity-nesting birds. It found that interdependencies among the species created a kind of community in which some species were crucial.

Trembling aspen is one such crucial species, accounting for

ERVIO SIAA

American Redstart

Yellow Warbler

Red-breasted Nuthatch

95 per cent of cavities used by nesting birds. Few cavities were excavated or used in conifers.

The 32 cavity-nesting species of birds subdivided into 8 species of primary excavating woodpeckers, 4 species of weak excavators such as nuthatches and chickadees, and 20 species of dependent non-excavators (ducks, sparrows, birds of prey). Two primary excavating species, northern flickers and red-naped sapsuckers, have a keystone role, providing 75 per cent of the nest holes used by other species.

The species tend to live together. Where primary excavators are abundant, so are secondary cavity nesters. A nest web, creating a hierarchy like a food web, seems to be an important factor in structuring forest bird communities. This means that impacts on nesting sites and excavating species can ripple through the community.

A lesson to be drawn from this study is that certain species have special importance to biodiversity. The large population of cavity-nesting birds in this ecosystem is almost totally dependent on one deciduous tree species and two woodpecker species.

ENCOURAGING ENVIRONMENTALLY SENSITIVE FORESTRY

With many partners, FRAP supported development of a variety of tools to help forest managers better understand and address ecological issues. They include the following:

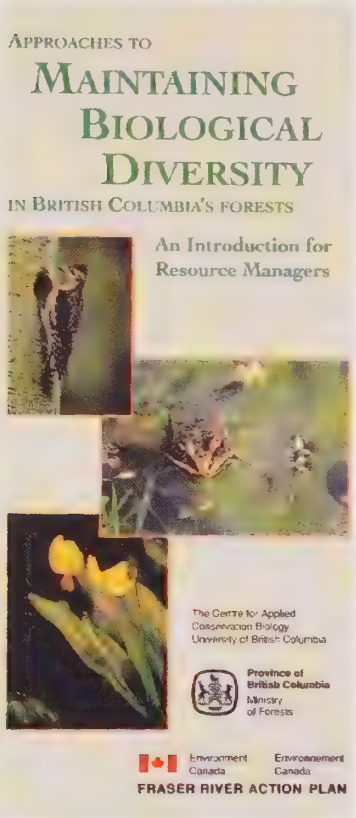
Operational pamphlets on biodiversity

FRAP supported the design and production of four pamphlets on forest biodiversity issues developed by the UBC Centre for Applied Conservation Biology and the provincial Ministry of Forests: Bald Eagles; Maintaining Biological Diversity in British Columbia's Forests; Rotten Luck: The Role of Downed Wood in Ecosystems; and Broad-leaved Trees: Unsung Component of British Columbia's Forests. Based on a review of

FRAP supported development of a variety of tools to help understand ecological issues

scientific literature and presented concisely and factually, they were designed to guide operational forest managers, planners, private property owners, and the interested public.

Thousands of copies of these pamphlets were distributed throughout the Fraser Basin to government agencies, companies, and schools.



FORTOON

This educational game puts high school students in the role of the Chief Forester, making decisions about where and what type of logging will be allowed in forest stands. Students learn about clearcutting, partial cutting, and other aspects of forest management and try to make decisions that will maintain jobs, profits, and wildlife habitat. FRAP supported development of the wildlife aspects of the supporting materials. The game will be distributed to schools by the National Film Board.

KATHLEEN MOORE

Riparian management workshop

In 1993, FRAP cosponsored a workshop on riparian habitat management which drew 140 participants, mainly federal and provincial biologists involved in riparian management and research. The purpose was to review the current state of knowledge and to develop recommendations for management. The workshop proceedings and summary document were published by FRAP and have become an important reference tool. The discussions and recommendations were used in developing guidelines under the provincial Forest Practices Code.

Biodiversity Training Module

FRAP sponsored development of toolkits and presentation materials for workshops on biodiversity. The intended audience was councils, boards, and staff of municipalities and regions, school trustees, environmental non-governmental organizations, land developers, and interested members of the public. The workshop materials explained biodiversity, described its range and state in British Columbia, and highlighted mechanisms to conserve it, especially in urban settings. A number of workshops were then held across the province using the material. Participants were enthusiastic, and many who were civic officials cited actions taken as a result, such as development guidelines, protection for riparian areas in subdivisions, and revisions to park plans to encompass biodiversity conservation.

WAYNE BELZER

EC AQUATICS SECTION

PROTECTING SENSITIVE AND IMPORTANT HABITAT

Protecting habitat in provincial land use planning

FRAP provided advice and information to provincial land use planning authorities for the regional Commission on Resources and the Environment (CORE) and the subregional Land and Resource Management Planning (LRMP) processes. FRAP's contributions led to greater recognition of the significance of sensitive habitats and ecosystems, such as wetlands, riparian areas, estuaries, and endangered species habitats. The importance of protecting migratory bird habitat was entrenched in the guiding policy document for LRMP. FRAP also cosponsored the first workshop for LRMP practitioners in Prince George, which brought together representatives from all sectors and contributed to the development of an LRMP manual for stakeholders. As a result, migratory bird habitat and sensitive ecosystems are being identified and protected throughout the Fraser Basin.

Migratory bird habitat and sensitive ecosystems are being identified and protected

CHRIS LAUSTRUP

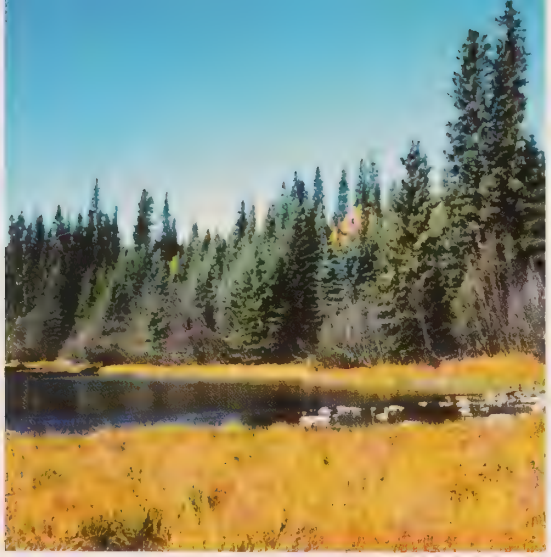
FRAP also contributed to the development of an LRMP training manual on First Nations issues. The module helps LRMP participants learn about First Nations' concerns and goals and work to develop First Nations' participation in the process.

BC MINISTRY OF ENVIRONMENT, LANDS AND PARKS

A baseline thematic map

Baseline thematic mapping

Maps of wetlands and other sensitive habitat do not exist across most of British Columbia because of the high cost of aerial photography and interpretation. This project, cosponsored by FRAP and the provincial Ministry of Environment, Lands and Parks, assessed the feasibility of using satellite imagery to map land use and vegetation cover. The project correlated satellite imagery with precisely known land use and vegetation information for two plots in the Quesnel Lake and Bonaparte Lake areas of the Fraser Basin. In this way, imaged features were linked with known physical characteristics, providing a reference that enables such images to be more easily interpreted.



EC AQUATICS SECTION

The success of the project persuaded the provincial government to extend the mapping process across the entire province. The result will be maps capable of identifying wetlands as small as 15 hectares in size to assist resource managers in planning for habitat conservation.

ECONOMIC INSTRUMENTS

In many areas, FRAP has investigated the feasibility of using economic instruments as an alternative to regulation. The idea is to alter behaviour not by prohibition and enforcement but rather by altering prices, which usually do not reflect true environmental costs. An example is to encourage recycling by charging for garbage disposal.

FRAP commissioned background research on opportunities for using such techniques in managing forest landscapes. One study suggested that measures such as variable stumpage rates or privatization of wildlife rights might be effective alternatives to regulation. A workshop on the issue brought interest and recommendations for further investigation.

FRASER RIVER ACTION PLAN

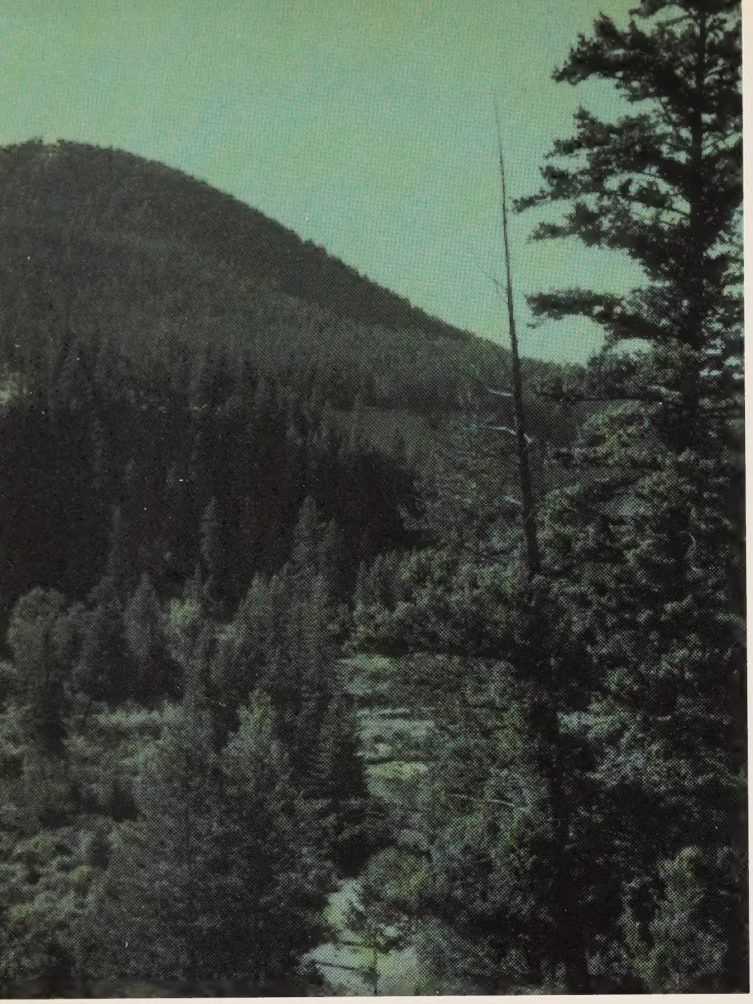
Our forests represent many values.

WHAT'S NEXT

environmental management

The forest industries face strong international competition at the same time as they are under increasing public pressure to reduce their environmental impacts. In the last decade they have responded vigorously with costly pollution-reduction programs that have brought dramatic results. They have proved that environmental management is consistent with maintaining competitiveness. The industry has developed and is benefiting from a new, cleaner image.

There is need for integrated research on the use of riparian habitat by birds, fish, and small and large mammals. The effects of forest practices on habitat remain controversial. Again, important improvements have begun, but continuing improvement will be required. Much further research on habitat, and the effects of forest practices, will be needed.

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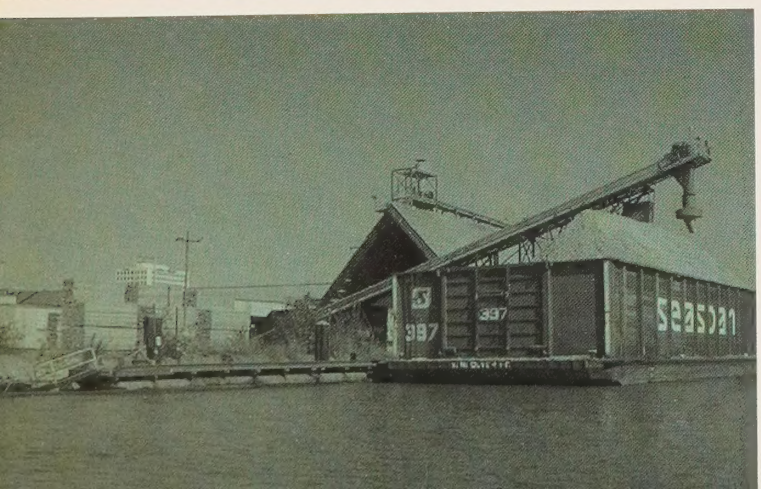
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